The role of social communication networks in implementing educational innovations in healthcare

Jippes, E.

The role of social communication networks
in implementing educational innovations in healthcare

Graphic design: Jan Kees Schelvis, SchelvisOntwerp, Haren gn
Print: EPC Printers, Budaörs, Hungary

ISBN/EAN: 978-90-367-5513-9

rijksuniversiteit groningen

The role of social communication networks in implementing educational innovations in healthcare

Proefschrift

ter verkrijging van het doctoraat in de
Economie en Bedrijfskunde
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. E. Sterken,
in het openbaar te verdedigen op
donderdag 31 mei 2012
om 14.30 uur

door

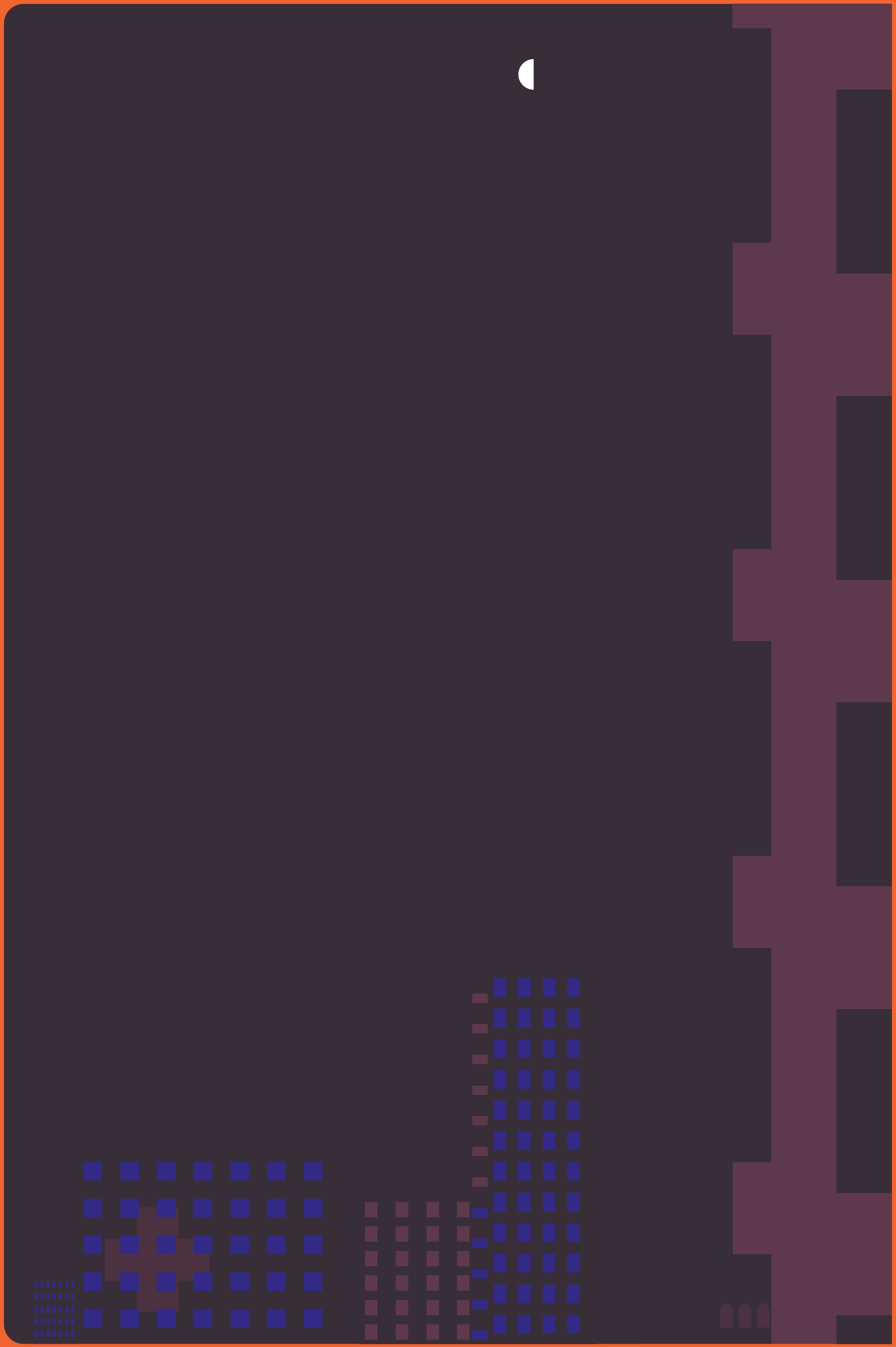
Erik Jippes

geboren op 1 september 1981
te Beilen

Promotores:	Prof. dr. Ir. J.M.L. van Engelen Prof. dr. P.L.P. Brand
Copromotores:	Dr. M.C. Achterkamp Dr. J. Pols
Beoordelingscommissie:	Prof. dr. P. Greenhalgh Prof. dr. R.T.A.J. Leenders Prof. dr. J. Cohen-Schotanus

Paranimfen: Marjon Leever
Mariëlle Jippes

Contents

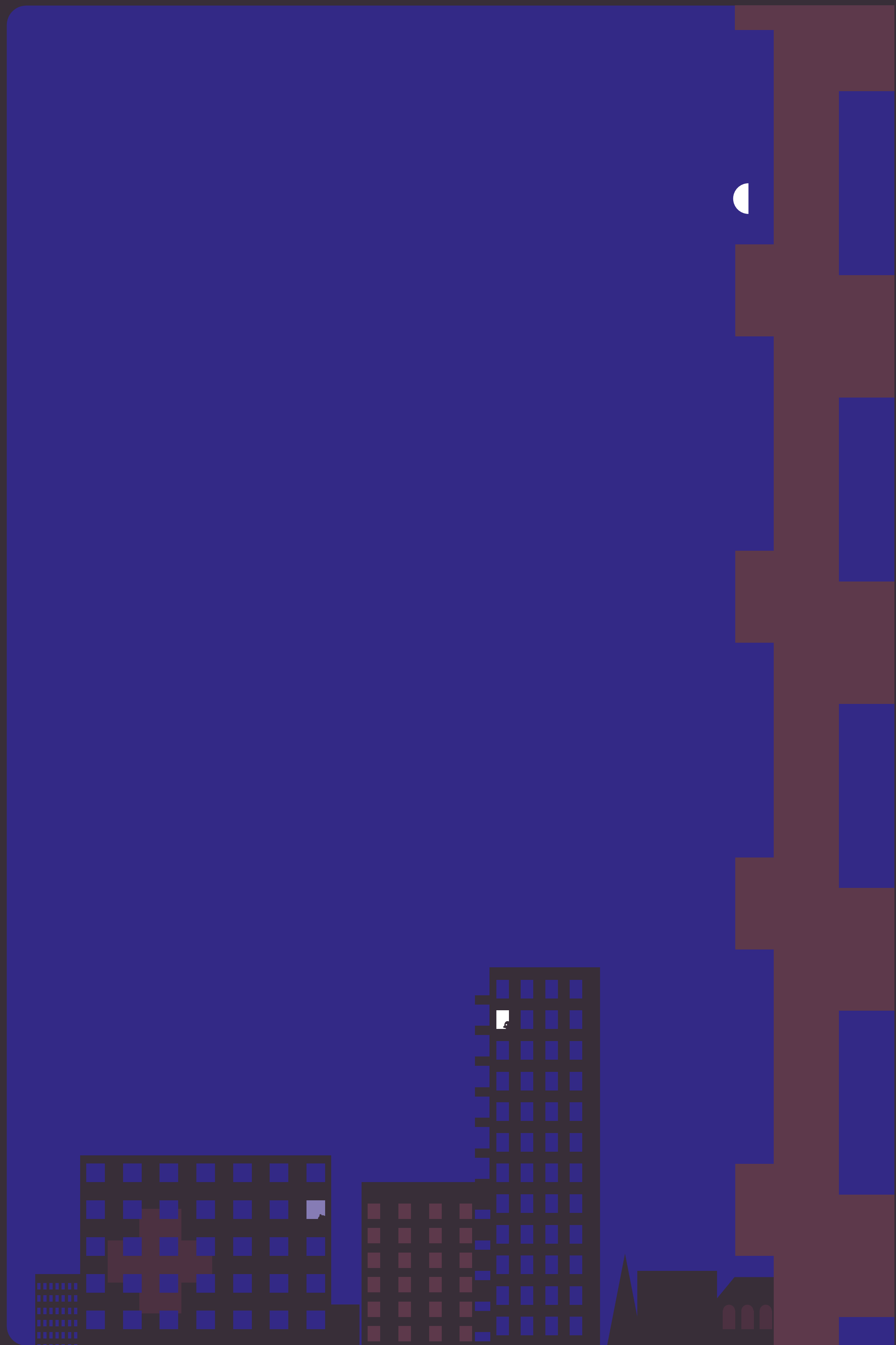


Chapter 1

Introduction

‘It ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.’

Niccolò Machiavelli (May 3, 1469 – June 21, 1527)



Problem statements: Social and practical relevance of the thesis

Physicians are faced with tremendous (in volume and speed) scientific developments and innovations. Approximately 400.000 references, including around 20.000 Randomized Controlled Trials, are added to the Medline database each year[1]. This means that physicians need to read around 1100 papers each day to keep up to date. The amount of papers for their own area of expertise may be a lot smaller, but still is a big number. Also the half-time of knowledge of physicians, which is the amount of time that has to elapse before half of the knowledge in a particular area is superseded or shown to be untrue, is decreasing every year[2]. There is evidence suggesting that physicians who have been in practice longer may be at risk for providing lower-quality care, because their knowledge is no longer up to date[3]. Besides reading new papers, physicians can follow training programs (such as courses, workshops and conferences) to keep up to date with relevant scientific developments and innovations. However, training programs are relatively costly in both time and money, and research indicates that following training programs does not automatically lead to the application of the newly learned knowledge[4].

So are there other, maybe more effective and efficient, ways for physicians to acquire new knowledge and keep up to date with regard to innovations? Increasingly research attention is being devoted to the role of social networks for this purpose. A social network can be defined as a finite set of actors and the relationships defined between them[5]. Social networks influence diffusion and adoption of innovations: (1) by functioning as channels for communication, social construction, and negotiation of the innovation; (2) by increasing the observability of the innovation; and, as a result, (3) by reducing any perceived risk through eliminating any novelty or uncertainty for the potential adopters of the outcome of the innovation[6,7]. Homophily and contagion are widely used concepts in spontaneous diffusion through social networks. Homophily is defined by Rogers (2003) as “the extent to which two or more individuals who interact are similar in certain attributes, education, social status and the like”. Homophily plays a large role in relationship building[8]. Between people who are more homophilous, contagion effects occur: an individual adapts his behavior, attitude, and beliefs to those of others, which enhances the diffusion of innovations[7].

Table 1
Empirical evidence on the role of social networks and spreading of knowledge[6]

- The structure of the social network (which is powerfully shaped by both organisational structure and professional norms) crucially influences the channels of communication of innovations
- Centralised networks (in which most decisions are made by the center / top of the organization) are most suitable for planned and targeted spreading of innovations
- Decentralised networks (in which most decisions are made by the periphery of the organization instead of the center / top) are most suitable for unplanned and spontaneous spreading of innovations
- Homophily is associated with high quality communication and powerful interpersonal influence which will affect the ease and spread with which the diffusion of an innovation takes place. Homophily is a fluid rather than fixed attribute; it can change when a certain innovation is introduced
- The individual network position (or actor centrality) in a particular social network is an important determinant how readily individuals will adopt.
  When the cumulative adoption is plotted in terms of actual adoption per period of time over the product life cycle, the result is a normal distribution. This can be used to classify adopters (S-adoption curve): the first people who adopt are innovators (2,5 percent), followed by early adopters (13,5 percent), early majority (34 percent), late majority (34 percent) and laggards (16 percent)
- External (weak) ties (or structural holes) allow new innovations to be identified and captured from outside the network. Individuals whose networks span structural holes have early access to diverse information, which provides them a competitive advantage in seeing good ideas and early access to innovations
- Some individuals (for example opinion leaders) have more social influence than others

Almost seventy years of research have shown that social networks are powerful mechanisms for distributing novel ideas and knowledge, also in healthcare[6]. For example, in the late sixties Coleman et al. (1966) studied the diffusion of a prescription drug Gammanym among 125 physicians in four American Midwestern communities. They found the more links and contacts a physician was involved in, the more likely he or she was to be an early user of Gammanym. Physicians who were more isolated in the network adopted the drug considerably later. The impact upon the integrated physicians was quick and strong, while the impact upon isolated physicians was slower and weaker, though not absent[9]. The most important findings on the influence of social networks on knowledge spreading were summarized by Greenhalgh et. al (2004), see Table 1. She conducted the most extensive systematic review currently available in the field of complex innovation in healthcare. After searching 6000 sources from different research traditions, nearly 500 sources of empirical evidence were included.

So both training programs and social networks can be considered mechanisms for transferring knowledge. Training programs can also be considered social networks; the program describes the set of actors (in this case the participants) and the relationships between them. An interesting situation emerges when one innovates the training programs themselves, as was the case with our innovation studied; the modernizations of the postgraduate medical education (PGME) programs in the Netherlands between 2004-2010.

Modernization of Postgraduate Medical Education in the Netherlands

Competency-based education is being increasingly introduced into PGME around the world[10]. Competency-based medical education (CBME) can be defined “as an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies”[11]. One popular approach towards CBME is the Canadian Medical Education Directions for Specialists (CanMEDS) framework[12]. The CanMEDS framework encompasses a set of seven roles for practicing specialists, derived from societal needs: medical expert, communicator, health advocate, collaborator, manager, scholar, and professional. Frank et al. (2010) describes a competency as “an observable ability of a health professional, integrating multiple components such as knowledge, skills, values and attitudes”.

Table 2
Mini-CEX and portfolio

Mini-CEX:
- Method to assess competencies in real life clinical practice[14]
- Consists of a short observation by a qualified medical specialist of a resident demonstrating clinical skills, using a pre-defined scoring format, followed by a structured feedback conversation[15]

Portfolio:
- In the portfolio, residents collect evidence documenting personal development according to the CanMEDS roles
- The results from the assessment instruments and evidence of acquired knowledge and skills are assembled, along with results of repeated reflection sessions on acquired competencies and a personal strengths-weaknesses analysis[16]

Table 3
Definitions of innovations

Innovation:
- The effective application of processes and products new to the organization and designed to benefit it and its stakeholders[18]

Product innovation:
- New products or services introduced to meet an external user or market need[19]

Process innovations:
- New elements introduced into an organization's production or service operations in order to produce a product or render a service[20]

Innovation-development process:
- All the decisions, activities, and their impacts that occur from recognition of a need or a problem, through research, development and commercialization of an innovation, through diffusion and adoption of the innovation by users to its consequences[7]

Innovation-decision process:
- The process "through which an individual passes from gaining initial knowledge of an innovation, to forming an attitude towards the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision[7]

continuation on page 16

The Royal Dutch Medical Association (RDMA) adopted the CanMEDS framework in 2004 for all PGME in the Netherlands, and they formulated 28 sub-competencies within the seven roles[13]. Furthermore, the RDMA introduced the Mini-Clinical Evaluation eXercise (Mini-CEX) and the portfolio (see Table 2).

There are 27 postgraduate training programs, in medical (e.g., internal medicine, pediatrics, neurology, dermatology), surgical (e.g., surgery, orthopedic surgery, gynecology, ear-nose-and-throat surgery), supportive (e.g., anesthesiology, emergency medicine) and diagnostic (e.g., radiology, microbiology, nuclear medicine) disciplines in the Netherlands. Every medical scientific society (in total 27, on a national level) in the Netherlands was requested by the RDMA to construct a competency-based PGME curriculum according to the seven roles, the 28 sub-competencies and the required assessment instruments. The medical scientific societies could receive support from the Dutch Advisory Board for Postgraduate Curriculum Development[16]. The training programs take place in a total of around 70 teaching hospitals (both university and general teaching hospitals). The program director – the medical specialist responsible for the training of residents in a particular team – was supposed to lead the actual implementation of the competency-based curriculum and the accompanying innovations (such as the Mini-CEX, see Table 2) in the department (local level). Residents in the Netherlands were supposed to receive their education according to the new competency-based PGME curricula beginning January 1st 2011[17]. Therefore, before this date, implementation of all competency-based PGME curricula in the Netherlands needed to be established.

We believe the implementation of the new competency-based PGME curricula in the Netherlands was very suitable for studying network effects. First of all, the RDMA and the medical scientific societies sent all information about the innovations to the program director. It is therefore reasonable to assume that all teams received equal information about the implementation of the new competency-based curricula, which makes "the innovation penetration" into the teams comparable across the teams. Second, another important item that was comparable across all teams was the way the information was spread across the team. In all teams, the primary responsibility for spreading the information to the medical specialists within the team, was attributed to the program director. Furthermore, this meant that for innovation adoption, the RDMA and the medical scientific societies heavily relied on the peer-to-peer

Table 3 *continuation*
Definitions of innovations

Diffusion:
- The process by which an innovation is communicated through certain channels among the members of a social system ("let it happen")[6]

Dissemination:
- Planned and active process intended to increase the rate and level of adoption above that which might have been achieved by diffusion alone ("make it happen"), actively spreading a message to defined target groups[6]

Implementation:
- Active and planned efforts to mainstream an innovation within an organization[6]

Systematic design:
- Systematic design intends to stimulate creativity while, at the same time, the controllability of the design process is increased significantly. Modern systematic design embraces a large and diverse set of methods and approaches but can be characterized along four underlying principles: *discursiveness* (semi-structured guidance for the design process through a step-by-step yet iterative scheme of activities), *hierarchical decomposition* (decomposing the design tasks into smaller easier to handle but interdependent subtasks and the formulation of several design specifications for the whole design problem) and *systematic variation* (searching for solutions for subtasks and combining these following the morphological scheme into solutions for the complete design task). To prevent designers from endlessly searching for ever better solutions the principle of *satisficing* was introduced by Simon in 1969. According to this principle searching for an acceptable solution is by far superior to searching for an optimal solution[21,22]

Knowledge:
- "Justified true belief", can be viewed as a state of mind, an object, a process, a stipulation of having access to information, or capability[23]

Knowledge management:
- The management of the context and environment for knowledge acquisition, representation, transformation, sharing, and use[24]

network effects between the program director and the other medical specialists in the team. Fourth, all teams were faced with introducing the same innovations; another comparable item across the teams. To summarize, we have well-grounded reasons to assume that the innovations penetrated the teams in the same way and that also the spreading of the innovations was comparable across the teams. Furthermore we had reasons to assume that network effects were important in this spreading process. This makes it all in all an excellent context to assess the independent effects of the social network effects between the medical specialists in the teams that train residents.

To summarize, in the Netherlands (1) the PGME training programs needed to be designed and (2) the training programs needed to be implemented (i.e. the innovations needed to be spread among the potential adopters; the residents, supervisors and program directors). As with the spreading of new technologies in healthcare, we expected social networks to be important for this spreading process as well as stated above, however the literature is scarce on this subject. We will elaborate on this in the next section. See Table 3 for an overview of several definitions on diffusion, dissemination and implementation of innovations.

The goal of this thesis was to advance the understanding of design and implementation of competency-based PGME curricula and to provide recommendations for medical professionals and policymakers regarding the implementation processes. This thesis addressed the following problem statements:

Problem statement 1: *How can we effectively and efficiently design a modernized competency-based PGME curriculum (knowledge creation)?*

Problem statement 2A): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general and more specifically…*

Problem statement 2B): *…with regard to the role of social networks in this transfer process?*

In the next section the problem statements will be translated into a conceptual model and research questions.

Table 4
Curriculum development steps in the (medical) educational literature[27]

1. Problem identification and general needs assessment, this includes the identification and critical analysis of a healthcare need or other problem
2. Targeted needs assessment, this involves the assessment of the targeted group and their learning needs, as well as an assessment of their learning environment
3. Goals and objectives, this involves the identification of goals and objectives of the curriculum, which may include cognitive (knowledge), affective (attitudinal), psychomotoric (skills and behavioural) objectives of the learner or process objectives related to the curriculum
4. Educational strategies, this involves the educational methods
5. Implementation, this involves the identification of resources, the obtainment of support (institutional, external), the development of administrative mechanisms, the anticipation on barriers and a plan for introducing the curriculum
6. Evaluation and feedback, this involves the achievement of objectives and stimulating continuous improvement

Table 5
The HORA project[28-30]

- HORA: Revision Curriculum Radiology (in Dutch Herziening Opleiding Radiologie)
- Divided into two projects: the design of the national curriculum of radiology (HORA 1) and nationwide implementation of the new curriculum in 26 radiology departments (HORA 2)
- The design (HORA 1) was started in 2005 and was ended in 2007
- The design team was composed of five radiologists and two educationalists
- The implementation (HORA 2) was started in 2008 and was ended in 2011
- The implementation team was composed of representatives (radiologists) of all eight regions of medical education in the Netherlands and an educationalist

Scientific relevance of the thesis

The design of the renewed competency-based PGME curricula (creation of new knowledge)

In the business literature, there is agreement that effectively structuring the innovation process is crucial for (commercial) success[19,25]. Four operations can be distinguished on a high abstraction level: generation, exploration, comparison, and selection[26]. In addition, the importance of four systematic design principles in innovation processes has been stressed: hierarchical decomposition, systematic variation, satisficing and discursiveness[22], see Table 3. The (medical) educational literature also contains many studies and textbooks on curriculum design. For example, Kern et al. (2009) described six distinct steps in curriculum development[27] (see Table 4).

Despite differences in the terminology used, both the content and the sequence of these steps are consistent across the educational literature. Steps 1, 2 and 3 can be viewed as components of the systematic design principle of hierarchical decomposition, breaking down the overall design into small, easy to handle, but interdependent subtasks, and formulating design specifications for the design as a whole. Although Kern et al.'s steps 1, 2 and 3 relate to design specifications, they do not include the decomposition of the design task into interdependent subtasks, nor do they take the other systematic design principles of discursiveness, systematic variation and satisficing into account. We believe that applying these design principles obtained from the business literature to the stepwise development of (medical) educational curricula constitute a useful extension to the existing literature on the subject. Chapter 2 of this thesis therefore describes the design of the new curriculum of Radiology – the "Herziening Opleiding Radiologie" or HORA project (see Table 5) – as well as the development process according to the systematic design principles. This chapter aimed to address the following methodological research question:

Research question 1: *How can we use systematic design methods to design a competency-based PGME curriculum?*

Table 6
The In VIVO project[40]

- In VIVO: Accelerating Innovation in PGME (in Dutch: Vaart In Innovatie VervolgOpleidingen)
- Encompassed the nationwide implementation of the training programs of Obstetrics and Gynecology (O&G) and Pediatrics
- Was set up as an example implementation project to distil critical success factors for implementing PGME curricula in the Netherlands
- The In VIVO project was started in 2006 and was ended in 2010
- The project was led by a national project team and eight regional implementation teams
- Encompassed 8 university medical centers and 36 general hospitals

The knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula

A lot of research has been done on knowledge transfer of innovations in businesses and healthcare. Greenhalgh et al. (2004) constructed a multi-level theoretical framework of complex innovation in health services organizations. Her framework includes promoting and impeding effects of many factors that she categorized under the main headings; attributes of the innovation, concerns of potential adopters, the wider environment, the implementation process, communication and influence, linkage between different parts of the system, organizational antecedents for innovation and organizational readiness for innovation[6,31,32].

Curriculum design and implementation in undergraduate medical education has also been well documented. Bland et al. (2000) summarized the available evidence into a conceptual framework which encompasses the following areas associated with successful curricular change; organizational mission and goals, history of organizational change, politics, organizational structure, need for change, scope and complexity of the innovation, and human resource development[33]. Also, the importance of national culture in the implementation of undergraduate medical education has been stressed[34].

Although it is universally agreed on that implementation of competency-based postgraduate medical education curricula involves a major challenge[16,35-38], the implementation process and the factors influencing it have received little attention in the literature. Only in Denmark the reform of PGME curricula has been documented. Whilst stakeholders had a positive attitude towards the task of developing new curricula, they found performance of this task quite difficult and gained insufficient support during the process[39]. The description of the Danish PGME curriculum reform lacks an underlying theoretical framework (which could have led to less accurate data collection and/or data interpretation processes) and the clinicians responsible for implementing and using the PGME curricula in practice were not interviewed (which could have led to less accurate findings, because the data on the actual implementation processes was missing).

Table 7

Examples of social networks involved in the renewal of competency-based PGME

National networks

- Network of the Royal Dutch Medical Association
- Network within and between scientific communities (e.g. the Dutch Radiology Society)
- Network within and between the residents' sections of the scientific communities
- Network of the Federation of University Medical Centers (NFU) and Society of Dutch Hospitals (NVZ)
- National educationalist network, mainly between educationalists in the Netherlands involved in the renewal of PGME

Regional networks

- Regional networks of program directors of the same specialty
- Regional educationalist network, mainly between educationalists within the regions involved in the renewal of PGME
- Network of the Board of Directors within and between regions of education

Local networks

- Local network of medical specialists within and between departments
- Local networks of central educational committees within the hospital
- Cross networks between the above networks

Therefore, in chapter 3 of this thesis, the implementation process of the revised competency-based PGME curricula of O&G and Pediatrics – the In VIVO project (see Table 6) – was evaluated using the Greenhalgh multi-level theoretical framework of complex innovation in health services organizations.

A qualitative approach was chosen in order to allow a detailed and context-rich description of the complex implementation process at the national, regional, and local levels, along with a description of the factors influencing this process. Despite the fact that these rich descriptions of complex implementation processes and impacts are highly valued, few of these are available in the literature[6]. Chapter 3 aimed to answer the following practical research question:

Research question 2: *What factors influence the implementation process of a competency-based PGME curriculum?*

The role of social networks in the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula

As with the spreading of new technologies in healthcare, we expected social networks to be important for the spreading of the innovations embedded in the renewed competency-based PGME curricula as well. Many people with different backgrounds in different positions (medical specialists, residents, educationalists, Board of Directors of hospitals, policy makers at the RDMA etc.) at different layers or levels (national, regional and local) were involved in the renewal of the competency-based PGME curricula in the Netherlands. Wallenburg et al. (2010) investigated which different perspectives exist on the renewal of competency-based PGME curricula among the actors involved. The study not only showed that different stake-holders were involved (hospital managers, policy makers, medical specialists, educational experts) but also that these stakeholders valued various aspects of the renewal process differently[41].

Within and between the different groups of stakeholders, social networks exist. For example, the RDMA introduced a national educationalist network to share best practices. Another example of a within-group stakeholder network is the national network of the scientific community. Each medical specialty has its own scientific community, with the so-called "concilium" as the leading board

Table 8

Definitions of network parameters

Network configuration:

- The structure of the network as a whole and has been extensively studied in relations to innovation (e.g.[43])

Centrality:

- Network centralization quantifies the range or variability of individual actor centralities. Actor centrality is the extent to which an individual is connected to other actors in the network[5]

Density:

- The proportion of possible lines compared to the maximum amount possible that are actually present in the network[5]. For example, consider a medium-sized department of around ten pediatricians. These ten pediatricians can be viewed as a social network in which ideas are being exchanged, day-to-day operations are being discussed etc. For this example, we consider the tie "information exchange" and we assume that this tie is "valued" and "nondirectional". Valued means that the tie can be placed on a continuum between, for example, never (score 1), weekly (score 2) and daily (score 3). Nondirectional means that we cannot distinguish the tie from from actor *i* to *j* and vice versa. The maximum amount of lines in this case is 270 (10 actors times 9 times 3). If all ten pediatricians have contact with each other on a weekly basis (180 lines), the resulting network density is .67

Segmentation:

- Highly segmented networks contain many subgroups with high within-group densities and low between-group densities. The social distances or shortest paths between persons not directly tied are greater in more segmented networks[5]. For example, the pediatrics department – as described above – would be highly segmented if two subgroups existed in the department of five pediatricians each; the pediatricians in each subgroup have contact with each other on a daily basis whereas the contact between persons in different subgroups is once a month

in the policy making and the assessment / accreditation for postgraduate medical education. As an illustration, Table 7 shows several (not exhaustive) social networks that are active in the renewal of competency-based PGME.

Although the multitude of networks involved suggests the importance of such social networks in the spreading of knowledge about the innovations introduced into PGME, the literature on this subject is scant[6]. Greenhalgh et al. (2004) concluded that, although the conceptual framework of social networks had been extensively applied to the adoption of particular health technologies, there was very little empirical literature on the social networks of health professionals as related to the diffusion of innovations in service delivery and organization.

In her review of social networks and teams, Henttonen (2010) suggested that the impact of social network parameters on team effectiveness may depend on the type of network in which the individuals are embedded. She therefore suggests replicating similar analyses, undertaken in other contexts, in new settings in order to build general theories[42]. Thus, on the one hand, the scientific relevance in this thesis concerned the replication of social network research undertaken in other context, to the context of competency-based PGME curricula.

Social network research encompasses a very broad spectrum of different parameters and theories. We focused on centrality, density and segmentation on both the individual network position level (of medical specialists) and the team network configuration level (of the teams of medical specialists that train residents) because these were expected to (1) be of high practical relevance; that means possible to be monitored, controlled and influenced by the primary adopters of the competency-based PGME (the program directors, supervisors and residents) and (2) be of high scientific relevance. See Table 8 for definitions of these network parameters.

Furthermore, we chose to concentrate the research on the local networks of medical specialists within departments. One the hand because on the local level we had a large number of teams that were comparable with respect to (1) the innovations introduced, (2) the innovation-penetration phase and (3) the innovation spreading phase, as stated previously.

Table 9
Control variables

Gender:

- Social networks among men and women differ in complex ways, particularly in relation to life stage[47]

Age:

- Older people tend to have larger and older networks which are less geographically proximal[48]. Age difference in network structure may reflect differing roles and possibilities according to life stage

Attitude towards the innovation:

- Meyers et al. (1999) hypothesized positive motivation, attitudes and commitment to the innovation as factors in facilitating implementation[49]. In healthcare, attitude and motivation also seem to be important for innovation[50]

Length of employment:

- Decker et al. (2001) found that the longer a person worked in an organization, the more negative the scoring on job satisfaction, the effect of budget adjustments on individual job-related stress, the quality of individual performance, and department morale[51]. On the other hand, it can be argued that length of employment actually has a positive influence on innovation. People with a longer work history in an organization (usually) have more (specific) knowledge and expertise which could assist innovation. Organizations must build on and maintain the resources and capabilities needed to compete[52]

Hours of employment:

- An increasing number of healthcare professionals have part-time appointments. Weick & Martin (2006) found no significant differences between part-time and full-time "inventors." They seemed to be similar in terms of age, gender, educational level, and the types of inventions they pursued[53]. Flexible working was found to be a consequence rather than a driver of product and process innovation[54]

Dissemination:

- Management can apply a more or less planned approach to spreading innovations in and between organizations; they can rely on the more or less natural process of diffusion (see Table 3) or add additional dissemination measures (see Table 3) to increase the rate and level of adoption[6]

continuation on page 28

On the other hand we chose the local level, because we wanted the results to be of high practical relevance to the primary adopters; the program directors, the supervisors and the residents.

All the network parameters in Table 8 concern the structural dimension of social networks and social capital theory*. The structure of the social network can be easily influenced by the primary adopters (high practical relevance). We chose centrality and density because these were embedded in a considerable body of research in other settings, so we were able to build on this research and extent it into the context of the renewal of PGME. We chose network segmentation because this still needs to be explored, but is considered a promising direction for further research[44] and because hospitals are characterized by high segmentation (many subcultures and subgroups)[45].

We wanted the individual network position of medical specialists / supervisors to be part of this thesis because we expected some medical specialists to be more influential than others which might explain variance in innovation adoption. In professional bureaucracies – like hospitals – collegial mechanisms (that means communication processes between peers) are most important in bringing about change[46].

Besides these individual network position effects, we expected strong effects of the network configuration on innovation adoption. We expected strong direct effects of the network configuration on innovation adoption, because – for example – a highly segmented network can pose barriers to the full spreading of knowledge among all adopters in a team. But we also expected strong moderating effects of the network configuration on the relationships between individual network position and innovation adoption. For example, a highly segmented network poses other challenges on the program directors' individual network position to influence their peers towards innovation adoption, then a network which is closely knitted together (highly dense network).

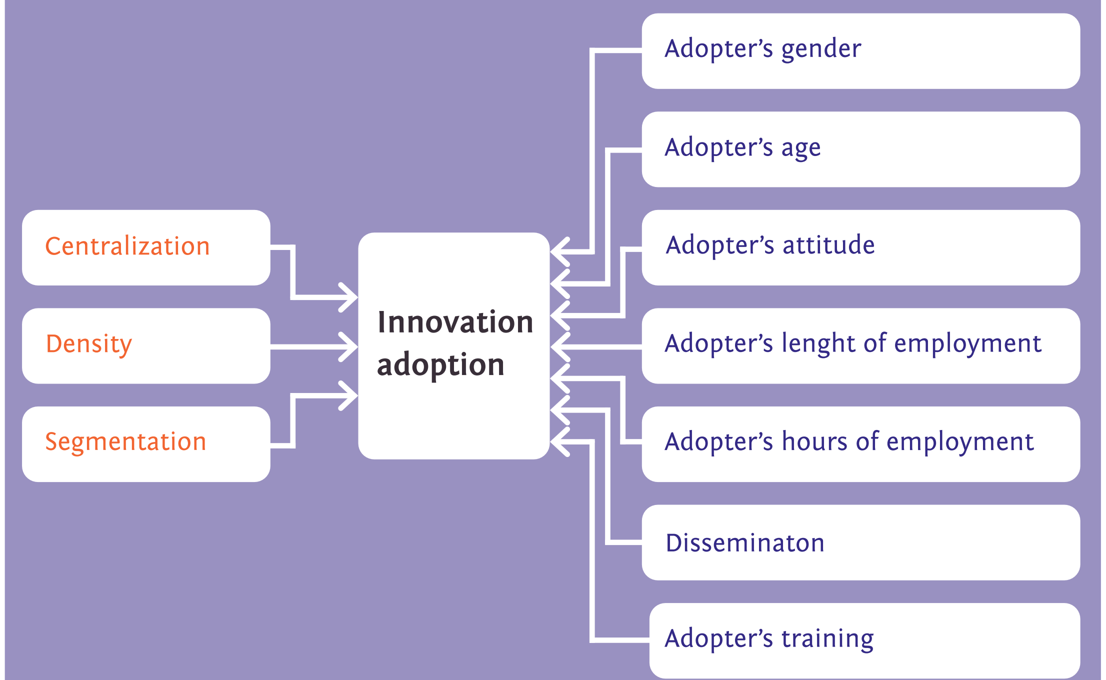
* Social capital can be defined as "the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organization"[64]. The structural dimension of social capital includes the patterns of relationships between the network actors which can be analyzed from the perspective of social network ties. Other dimensions are cognitive, and relational. The cognitive dimension includes shared meaning and understanding between network actors. The role of direct ties and their outcomes, such as trust, norms, and identification, is part of the relational dimension of social capital[65].

Table 9 *continuation*
Control variables

Training:

- Steinert et al. (2006) conducted a review of the effectiveness of teaching faculty development initiatives in medical education. They defined faculty development as those planned programs which prepare institutions and faculty members for their academic roles, including teaching, research, administration, writing, and career management. Steinert et al. limited their review to faculty members' teaching abilities in medicine. Faculty development activities appeared to be highly valued by the participants, who also reported changes in learning and behavior. However, student/resident evaluations did not always reflect the behavioral changes that the participants perceived, and changes in organizational practice and student learning have not been investigated very frequently since[4]

Figure 1
Conceptual model social network part of the thesis



We controlled for effects of supervisor's gender, age, attitude towards the innovations introduced, length of employment, hours of employment, dissemination and training (see Table 9).

In Figure 1 the resulting conceptual model (containing the independent, dependent and control variables) on the social network part of this thesis is presented.

The dependent variable consists of the adoption of the innovations embedded in the renewed competency-based PGME curricula. We are convinced that these can be considered genuine innovations, since whether an idea, concept, method, product, or service is considered an innovation is dependent on the newness for the adopting organization (see Table 3). Something can be new and innovative for one organization, whilst other organizations have already adopted it. The introduction of the competency-based curricula, including its teaching methods and assessment instruments, were new and innovative to the medical scientific societies and the medical professionals responsible for PGME in the hospitals[40].

Furthermore, the thesis focuses on adoption, or more specifically on "degree of innovation adoption". The adoption decision – as shown in Table 3 – of the innovation studied in this thesis can not be easily established in a simple yes or no, it is more a matter of degree of adoption. In addition, the dependent variable – in the social network part of this thesis – is operationalized as the adoption of the innovation "structured and constructive feedback", using Pendleton's rules (see Table 10).

Structured and constructive feedback is one of the key changes introduced into the renewed programs. Before 2004, feedback in PGME, if offered at all, was given in an unstructured and sometimes derogatory manner (e.g.[55,56]). Structured and constructive feedback is also a more general innovation that needed to be spread amongst all medical specialties. To summarize, our dependent variable consists of the "degree of innovation adoption of the innovation structured and constructive feedback".

Before we can present the specific scientific research questions that will be addressed on the social network part of this thesis, we will elaborate on the specific theories that were used in combination with the chosen social network parameters. The conceptual model

Table 10

Pendleton's rules of feedback[15]

- The feedback is structured
- The supervisor gives the trainee (resident) the opportunity to give his/her opinion on his/her performance
- The supervisor provides points that went well
- The supervisor provides specific points for improvement
- The supervisor provides the feedback in a constructive and supportive ("safe") fashion

as presented in Figure 1 was not assessed entirely in one single model and in one article. Instead, parts of the conceptual model and the theories were combined in order to condense and target the articles and therefore enhance publication possibilities. This resulted in three specific scientific research questions, as we will explain in the following.

First, we made use on the extensive body of research conducted on spreading new products or services
into a market. After recognition of a need or a problem, research, development and commercialization of an innovation, the innovation needs to be spread amongst the intended market[57]. Management can choose between diffusion and dissemination in order to engineer the market introduction and the spreading process (see Table 3). Diffusion is primarily dependent on the structure of the social network. This structure is always present and can be more or less conducive to the diffusion process. On the other hand, management can try to disseminate the innovation. Dissemination consists primarily of process measures taken by management to increase the rate and level of adoption. Although many studies have evaluated the effectiveness of the diffusion or dissemination approaches alone, none have compared the integral effects of both approaches in terms of the rate and level of adoption of a particular innovation.

Therefore, chapter 4 of this thesis addresses the integral effects of both diffusion and dissemination approaches on innovation adoption. Data on diffusion (as measured by network density) and dissemination (as measured by formulating objectives and executing focused activities) was gathered. Chapter 4 aimed to answer the following scientific research question:

Research question 3: *What is the influence of a diffusion approach ('let it happen'-social network density model) on PGME innovation, compared to a dissemination approach ('make it happen'-process management models)?*

Table 11

Summary of problem statements, conceptual model, research questions and chapters

Problem statements	Theory and conceptual model	Research questions	Chapters
Problem statement 1: How can we effectively and efficiently design a modernized competency-based PGME curriculum (knowledge creation)?	• Systematic design methods	**Research question 1:** How can we use systematic design methods to design a competency-based PGME curriculum? (= methodological research question)	2
Problem statement 2A: How can we improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general and…	• Diffusion of innovation theory	**Research question 2:** What factors influence the implementation process of a competency-based PGME curriculum? (= practical research question)	3
Problem statement 2B: …more specifically with regard to the role of social networks in this transfer process?	• Network density • Dissemination	**Research question 3:** What is the influence of a diffusion approach (let it happen'-social network density model) on PGME innovation, compared to a dissemination approach ('make it happen'-process management models)? (= scientific research question)	4

continuation on page 34

Second, we combined the social network parameter centrality with the research on training. Many studies have been conducted on training in general (e.g.[58]), training in business (e.g.[49]) and training of program directors and supervisors in medical education (e.g.[4,59]). Both training and social networks may be regarded as valuable mechanisms for transferring knowledge, as was stated earlier in this introduction. Interestingly, no studies have been conducted comparing the effects of both mechanisms simultaneously on the effectiveness of knowledge transfer. Therefore, in chapters 5 and 6 we aimed to answer the following scientific research question:

Research question 4: *What is the influence of following an intensive Teach-the-Teacher course on PGME innovation, compared to the adopter's individual network position (centrality)?*

Chapter 5 describes a study containing 81 medical specialists. To validate our findings we conducted another study (described in chapter 6) with 370 medical specialists and analyzed the results using hierarchical linear modelling allowing better assessment of the regression coefficients and error components. Because of the smaller number of medical teams involved, we were unable to use hierarchical linear modelling in the study described in chapter 5. Another addition in the chapter 6 study is the inclusion of both the self-assessment by medical specialists of their innovation adoption and the resident assessment of innovation adoption. Chapter 5 contains only the resident assessment. The inclusion of both assessments provides valuable insights in how adopters perceive their adoption compared to sources externally to the adopter.

Third, we combined the work on actor centrality, network density and network segmentation to the theories on leadership and innovation. Over the years different theories, ranging from the early trait theories and contingency theories, to the more recent transformational, neo-charismatic, and information-processing theories, have tried to explain the relationship between leadership on the one hand, and (group) performance and innovation on the other[60].

Despite the vast amount of studies on leader-member exchange (LMX), which have focused mainly on the quality of dyadic relationships between the leader and the subordinate, relatively few studies

Table 11 *continuation*

Summary of problem statements, conceptual model, research questions and chapters

Problem statements	Theory and conceptual model	Research questions	Chapters
	• Actor centrality • Training	**Research question 4:** What is the influence of following an intensive Teach-the-Teacher course on PGME innovation, compared to the adopter's individual network position (centrality)? (= scientific research question)	5, 6
	• Actor centrality • Network density • Network segmentation	**Research question 5:** What is the influence of the leaders' network position on PGME innovation and when moderated by the social network configuration, more specifically network density and network segmentation? (= scientific research question)	7, 8

have examined the leaders' cognition of their wider social networks, and the influence that the structure of leaders' ties with their team members has on (group) performance and innovation[61-63]. Chapters 7 and 8 aimed to fill this gap and looked into the actor centralities of the program directors (leader centrality).

The program director is the medical specialist who is formally assigned by the RDMA to be responsible for PGME of a specific specialty in a hospital. The effect of different leader (program director) actor centralities on their followers' (clinical supervisors') innovation adoption was assessed in chapter 7, while chapter 8 describes the moderating effect of network configuration (density and network segmentation) on the leader centrality – follower innovation adoption relationship. The conceptual development of the different leader centralities and the moderating effects of the network configuration, as well as the empirical testing, have not been documented before. In chapters 7 and 8 the following scientific research question was addressed:

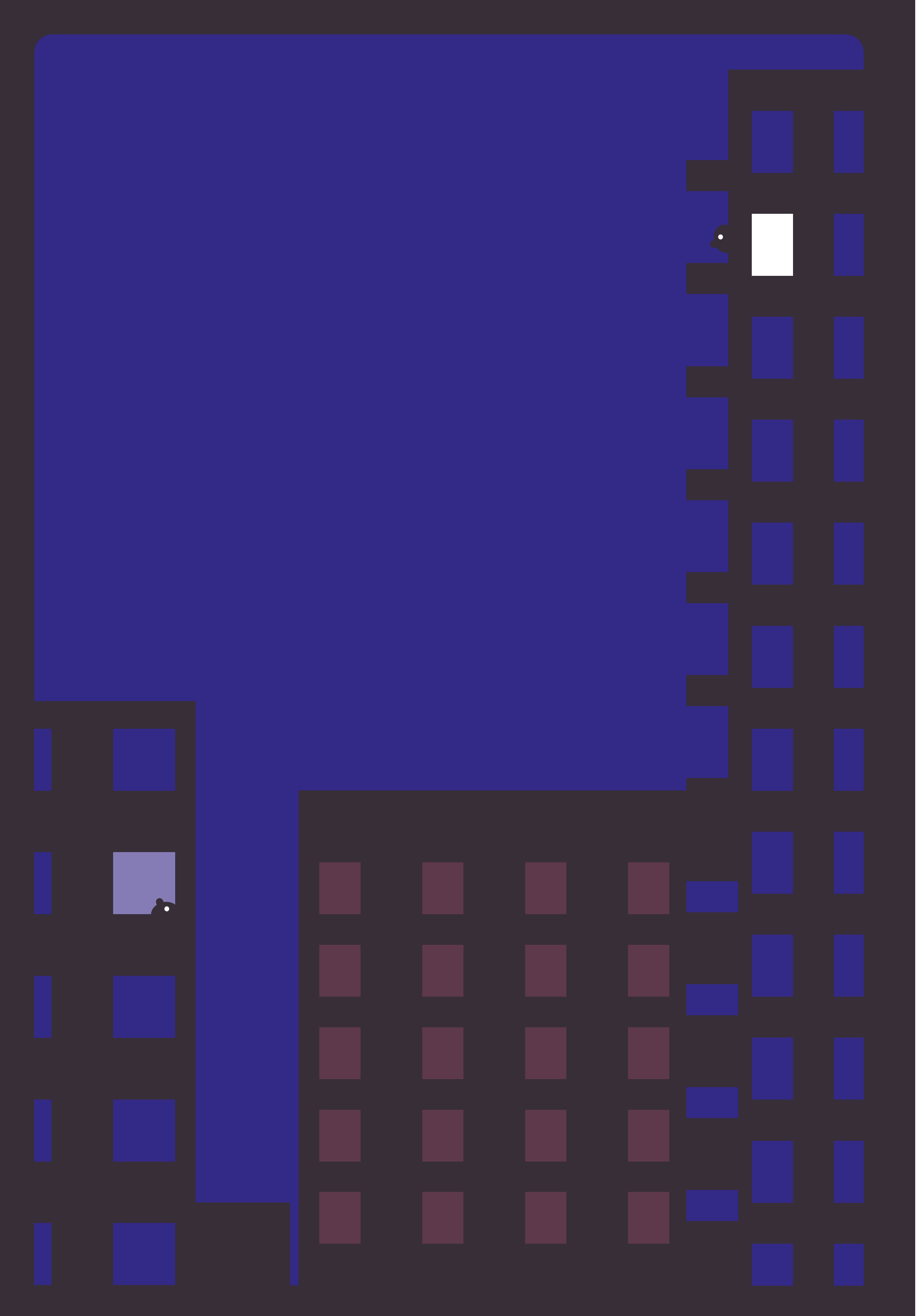
Research question 5: *What is the influence of the leaders' network position on PGME innovation and when moderated by the social network configuration, more specifically network density and network segmentation?*

Table 11 provides a summary of the problem statements, the conceptual model, research questions (methodological, practical and scientific) and the chapters in which these research questions are addressed.

References

1. Glasziou P. *How can we prepare students to the information flood.* Trondheim: AMEE Conference; 2007.
2. Long LN, Schweitzer SJ. Information and knowledge transfer through archival journals and on-line communities. 42nd AIAA aerospace sciences meeting and exhibit, 5 January 2004 through 8 January 2004, Reno, NV.;10206-16.
3. Choudhry NK, Fletcher RH, Soumerai SB. Improving patient care. systematic review: The relationship between clinical experience and quality of health care. *Ann Intern Med.* 2005;142:260.
4. Steinert Y, Mann K, Centeno A, Dolmans D, Spencer J, Gelula M, et al. A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME guide no. 8. *Med Teach.* 2006;28:497-526.
5. Wasserman S, Faust K. *Social network analysis.* Cambridge: Cambridge University Press; 1994.
6. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
7. Rogers EM. *Diffusion of innovations.* New York: Free Press; 2003.
8. Gibbons D. Interorganizational network structures and diffusion of information through a health system. *Am J Public Health.* 2007;97:1684-92.
9. Coleman JS, Katz E, Menzel E. *Medical innovation: A diffusion study.* New York, NY: The Bobbs-Merrill Company, Inc; 1966.
10. Frank J, Mungroo R, Ahmad Y, Wang M, De Rossi S, Horsley T. Toward a definition of competency-based education in medicine: A systematic review of published definitions. *Med Teach.* 2010;32:631-7.
11. Frank J, Snell L, Cate O, Holmboe E, Carraccio C, Swing S, et al. Competency-based medical education: Theory to practice. *Med Teach.* 2010;32:638-45.
12. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach.* 2007;29:642-7.
13. Royal Dutch Medical Association - Koninklijke Nederlandsche Maatschappij tot Bevordering der Geneeskunst. Resolution (kaderbesluit) CCMS 2004. *Staatscourant.* 2004;Febr 9 2003.
14. Norcini J, Blank L, Duffy FD, Fortna G. The mini-CEX: A method for assessing clinical skills. *Ann Intern Med.* 2003;138:476-81.
15. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication.* Oxford: Oxford University Press; 2003.
16. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach.* 2008;30:248-53.
17. Royal Dutch Medical Association - Koninklijke Nederlandsche Maatschappij tot Bevordering der Geneeskunst. Resolution (kaderbesluit) CCMS 2009. *Staatscourant.* 2009;Nov 18 2009.
18. West MA, Anderson NR. Innovation in top management teams. *J Appl Psychol.* 1996;81:680-93.
19. Kotler P, Armstrong G, Brown L, Adam S. *Marketing.* Pearson Education Australia; 2006.
20. Baregheh A, Rowley J, Sambrook S. Towards a multidisciplinary definition of innovation. *Man Decis.* 2009;47:1323-39.
21. Simon HA. *The sciences of the artificial.* MA: MIT Press; 1969.
22. Leenders RTAJ, van Engelen JML, Kratzer J. Systematic design methods and the creative performance of new product teams: Do they contradict or complement each other? *J Prod Inn Man.* 2007;24:166-79.
23. Nonaka I. A dynamic theory of organizational knowledge creation. *Org Sci.* 1994;5:14-37.
24. Small CT, Sage AP. Knowledge management and knowledge sharing: A review. *Inf Know Sys Man.* 2006;5:153-69.
25. Ernst H. Success factors of new product development: A review of the empirical literature. *Int J Man Rev.* 2002;4:1.
26. Stempfle J, Badke-Schaub P. Thinking in design teams - an analysis of team communication. *Des Stud.* 2002;23:473.
27. Kern DE, Thomas PA, Hughes MT. *Curriculum development for medical education: A six-step approach.* Baltimore, Maryland: The Johns Hopkins University Press; 2009.
28. Jippes E, Oudkerk M. Op weg naar één curriculum en acht opleidingen radiologie. *Memorad.* 2008;13:5-7.
29. Jippes E, Gratama JWC, Oudkerk M. Concilium radiologicum - HORA 2 commissie. *Memorad.* 2010;15:7-9.
30. Jippes E, Brand PLP, van Engelen JML, Oudkerk M. Competency-based (CanMEDS) residency training programme in radiology: Systematic design procedure, curriculum and success factors. *Eur Radiol.* 2010;20:967-77.
31. Greenhalgh T, Stramer K, Bratan T, Byrne E, Mohammad Y, Russell J. Introduction of shared electronic records: Multi-site case study using diffusion of innovation theory. *Br Med J.* 2008;337:1040-4.
32. Greenhalgh T, Stramer K, Bratan T, Byrne E, Russell J, Potts H. Adoption and non-adoption of a shared electronic summary record in england: A mixed-method case study. *Br Med J.* 2010;340:1399-.
33. Bland C, Starnaman S, Wersal L, Moorhead-Rosenberg L, Zonia S, Henry R. Curricular change in medical schools: How to succeed. *Acad Med.* 2000;75:575-94.
34. Jippes M, Majoor GD. Influence of national culture on the adoption of integrated medical curricula. *Adv Health Sci Educ Theory Pract.* 2011;16:5-16.
35. Ringsted C, Østergaard D, vd Vleuten CP. Implementation of a formal in-training assessment programme in anaesthesiology and preliminary results of acceptability. *Acta Anaes Scand.* 2003;47:1196-203.
36. Ten Cate O, Scheele F. Competency-based postgraduate training: Can we bridge the gap between theory and clinical practice? *Acad Med.* 2007;82:542-7.
37. Lurie S, Mooney C, Lyness J. Measurement of the general competencies of the accreditation council for graduate medical education: A systematic review. *Acad Med.* 2009;84:301-9.
38. Wasnick J, Chang L, Russell C, Gadsden J. Do residency applicants know what the ACGME core competencies are? one program's experience. *Acad Med.* 2010;85:791-3.

39. Lillevang G, Bugge L, Beck H, Joost-Rethans J, Ringsted C. Evaluation of a national process of reforming curricula in postgraduate medical education. *Med Teach.* 2009;31:260-6.
40. In-VIVO project. Implementation project in-VIVO starts october 17th 2006. *www.medischevervolgopleidingen.nl* 2006.
41. Wallenburg I, van Exel J, Stolk E, Scheele F, de Bont A, Meurs P. Between trust and accountability: Different perspectives on the modernization of postgraduate medical training in the netherlands. *Acad Med.* 2010;85:1082-90.
42. Henttonen K. Exploring social networks on the team level - A review of the empirical literature. *J Eng & Techn Man.* 2010;27:74-109.
43. Reagans R, Zuckerman E, McEvily B. How to make the team: Social networks vs. demography as criteria for designing effective teams. *Adm Sci Q.* 2004;49:101-33.
44. Kratzer J, Leenders RTAJ, van Engelen JML. Informal contacts and performance in innovation teams. *Int J Manp.* 2005;26:513-28.
45. Bate P. Changing the culture of a hospital: From hierarchy to networked community. *Publ Adm.* 2000;78:485.
46. Mintzberg H. *The structuring of organizations.* Englewood Cliffs: Prentice-Hall; 1979.
47. Antonucci T. Social relations: An examination of social networks, social support, and sense of control. In: Birren J, Schaie KW, editors. Handbook of the psychology of aging (5th ed.). San Diego, CA, US: Academic Press; 2001. p. 427-53.
48. Ajrouch K, Blandon A, Antonucci T. Social networks among men and women: The effects of age and socioeconomic status. *J Ger Ser B: Psych Sci & Soc Sci.* 2005;60:311-7.
49. Meyers P, Sivakumar K. Implementation of industrial process innovations: Factors, effects, and marketing implications. *J Prod Inn Man.* 1999;16:295-311.
50. Garcia-Goni M, Maroto A, Rubalcaba L. Innovation and motivation in public health professionals. *Health Pol.* 2007;84:344-58.
51. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man.* 2001;19:1-12.
52. Grant R. *Contemporary strategy analysis: Concepts, techniques, applications.* Malden MA: Blackwell Publishers; 2001.
53. Weick C, Martin J. Full-time and part-time independent inventors: Rising with the creative class. *Int J Entr & Inn.* 2006;7:5-12.
54. Storey J, Quintas P, Taylor P, Fowle W. Flexible employment contracts and their implications for product and process innovation. *Int J Hum Res Man.* 2002;13:1-18.
55. Vd Hem-Stokroos HH, Scherpbier AJ, vd Vleuten CP, de Vries H, Haarman HJ. How effective is a clerkship as a learning environment? *Med Teach.* 2001;23:599-604.
56. Busari JO, Weggelaar NM, Knottnerus AC, Greidanus PM, Scherpbier AJ. How medical residents perceive the quality of supervision provided by attending doctors in the clinical setting. *Med Educ.* 2005;39:696-703.
57. Debruyne M, Moenaert R, Griffin A, Hart S, Hultink E, Robben H. The impact of new product launch strategies on competitive reaction in industrial markets. *J Prod Inn Man.* 2002;19:159-70.
58. Arthur J, Bennett J, Edens P, Bell S. Effectiveness of training in organizations: A meta-analysis of design and evaluation features. *J Appl Psychol.* 2003;88:234-45.
59. Rubak S, Mortensen L, Ringsted C, Malling B. A controlled study of the short- and long-term effects of a train the trainers course. *Med Educ.* 2008;42:693-702.
60. Gardner W, Lowe K, Moss T, Mahoney K, Cogliser C. Scholarly leadership of the study of leadership: A review of the leadership quarterly's second decade, 2000-2009. *Lead Q.* 2010;21:922-58.
61. Balkundi P, Kilduff M. The ties that lead: A social network approach to leadership. *Lead Q.* 2005;16:941-61.
62. Galvin BM, Balkundi P, Waldman DA. Spreading the word: The role of surrogates in charismatic leadership processes. *Acad Man Rev.* 2010;35:477-94.
63. Brass D, Galaskiewicz J, Greve H, Wenpin T. Taking stock of networks and organisations: A multilevel perspective. *Acad Man J.* 2004;47:795-817.
64. Inkpen A, Tsang E. Social capital, networks, and knowledge transfer. *Acad Man Rev.* 2005;30:146-65.
65. Nahapiet J, Ghoshal S. Social capital, intellectual capital, and the organizational advantage. *Acad Man Rev.* 1998;23:242-66.



Chapter 2

Competency-based (CanMEDS) residency training programme in radiology: systematic design procedure, curriculum and success factors

Erik Jippes
Jo M.L. van Engelen
Paul L.P. Brand
Matthijs Oudkerk

Published in *European Radiology* 2010; 20:967-977

Abstract

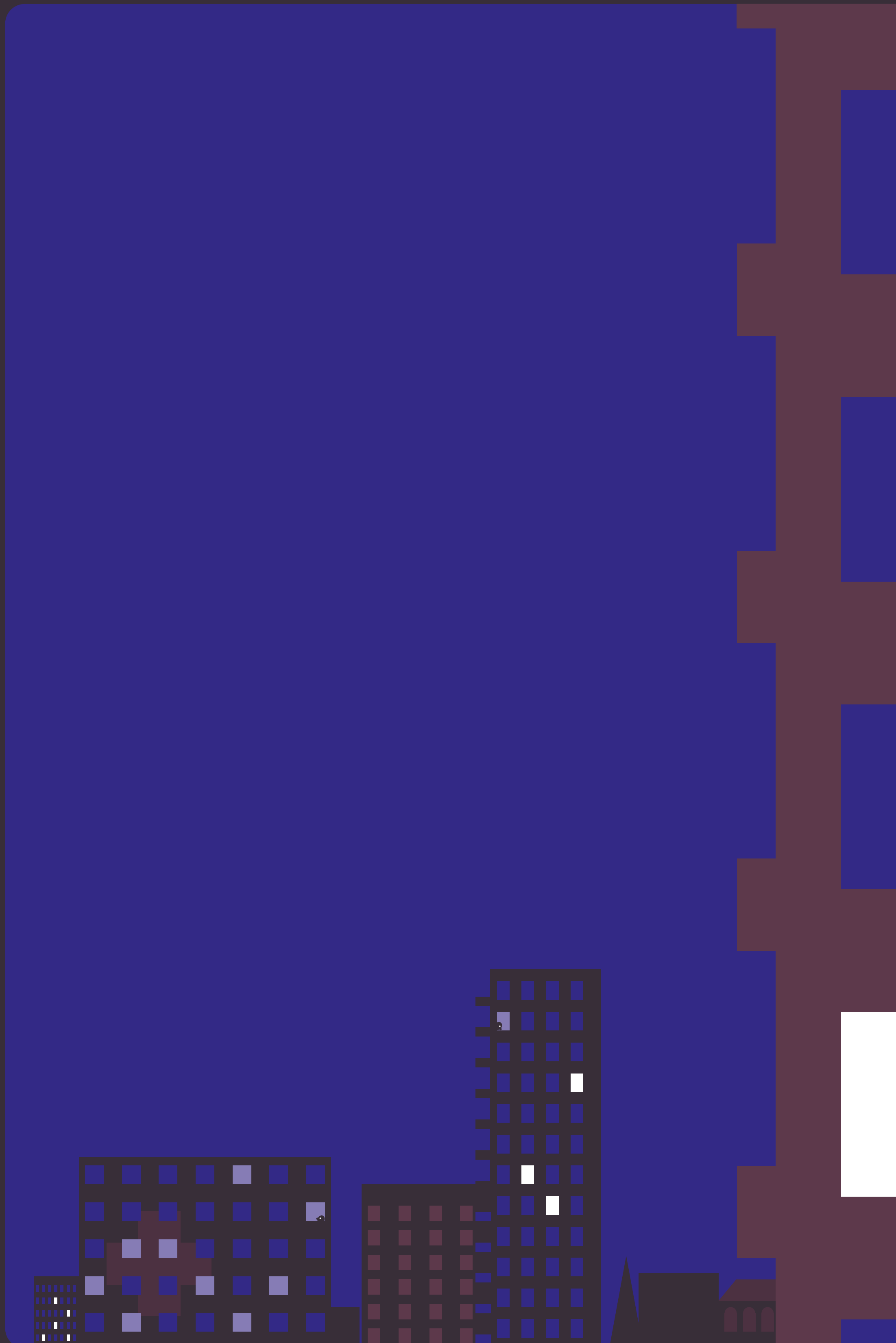
Objective: Based on the CanMEDS framework and the European Training Charter for Clinical Radiology a new radiology curriculum was designed in the Netherlands. Both the development process and the resulting new curriculum are presented in this paper.

Methods: The new curriculum was developed according to four systematic design principles: discursiveness, hierarchical decomposition, systematic variation and satisficing (satisficing is different from satisfying; in this context, satisficing means searching for an acceptable solution instead of searching for an optimal solution).

Results: The new curriculum is organ based with integration of radiological diagnostic techniques, comprises a uniform national common trunk followed by a 2-year subspecialisation, is competency outcome based with appropriate assessment tools and techniques, and is based on regional collaboration among radiology departments.

Discussion: The application of the systematic design principles proved successful in producing a new curriculum approved by all authorities. The principles led to a structured, yet flexible, development process in which creative solutions could be generated and adopters (programme directors, supervisors and residents) were highly involved. Further research is needed to empirically test the components of the new curriculum.

Keywords: Radiology education, Medical education, Curriculum development. Systematic design procedures, Diffusion of innovation, The Netherlands.



Introduction

Based on the Canadian Medical Education Directions for Specialists (CanMEDS)[1] framework of key competencies for medical specialists the Royal Dutch Medical Association (RDMA) decided in 2004 that postgraduate training and education for all medical specialists in the Netherlands should be reformed. In the same year, the national Board of Health Care Professions and Education (BHCPE) in the Netherlands was instituted, in which decisions on structure, innovation, quality (monitoring) and finances of all medical specialty training programmes were integrated[2]. The Netherlands was divided up into eight regions for medical education to coordinate postgraduate training in each region[3].

In 2006, the Dutch Radiology Society (DRS) assigned a national project team (Revision of Radiology Curriculum, “Herziening Opleiding Radiologie” or HORA in Dutch) with the task of developing a new radiology training curriculum, taking into account guidelines both from the RDMA and from the European Association of Radiology (EAR), a collaboration of national scientific radiological societies in Europe, which published the European Training Charter for Clinical Radiology (ETCC), an outline for an organ-based curriculum comprising a common trunk and a subspecialty programme in 2005[4]. The multitude of both the complex developments and the stakeholders in a variety of fields involved turned the accomplishment of the HORA project into a great challenge. We, therefore, decided to apply a systematic development approach based on evidence-based design principles. Both the development process and the resulting new curriculum[5] are presented in this paper.

Materials and methods

The Concilium Radiologicum (National Board for Education and Training in Radiology) of the DRS put together the HORA project team with experienced university and general hospital radiologists, residents and educationalists. The project team realised that the construction of a new curriculum comprised two major areas.

The first major area comprises, the medical knowledge of radiology, radiological procedures and radiology organisation (the content of the new curriculum) which was based on the ETCC[4] and put together by the experienced radiologists and radiology residents in the project team. The ETCC formed a valuable starting point for multiple reasons. First of all, many authoritative and experienced radiologists from almost all national scientific radiological societies in Europe worked on this charter for years. Using these valuable insights saved time and energy. Second, the charter was officially approved by the EAR which committed the DRS. Third, using an officially approved European charter helped in gaining acceptance from the programme directors in the Netherlands for the curriculum changes. The ETCC was translated by an experienced medical translator in Dutch and corrected by the radiologists in the project team. The radiologists in the project team took into account that the increased technological possibilities of magnetic resonance imaging (MRI) and computed tomography (CT), and the implementation of picture archiving communication systems (PACS) have increased the diagnostic capabilities and efficiency of radiology departments. This increases not only the workload of the radiology department, but also the specialised knowledge required by the radiologist to effectively use these diagnostic capabilities to answer clinicians' questions. It was assumed that future radiologists will increasingly engage in multidisciplinary collaboration with clinicians, and that interventional radiology will be a rapidly evolving field, shifting towards more minimally invasive procedures[6,7]. The residents in the project team advocated the interests of their fellow residents and were responsible for communicating the developments in the new curriculum to them. The residents in the project team were first contact for questions of their fellow residents.

The second major area comprises the educational outline and the toolbox of the curriculum which was provided by the Dutch version of the CanMEDS competency-based framework and the corresponding (mandatory) assessment instruments. The educationalists in the project team advised the radiologists how to translate the general framework to the context of radiology. Although different medical specialists show similarities in the competencies they are supposed to possess, important differences can occur between different specialties, however. For example, the competency "communicator" will be interpreted differently for a psychiatrist and a radiologist. For the psychiatrist, verbal communication is at the heart of the diagnostic and therapeutic repertoire, whilst digital or written communication is more important in the radiological service. Translation of the general framework to every medical specialty is therefore necessary to make the framework practical and meaningful. In this process, the educationalists gave advice on the building blocks of the curriculum, assessment strategy and instruments, quality control and implementation. Furthermore, the educationalists were responsible for coordinating the different (sub)tasks in the design of the new curriculum. Other activities of the educationalists included the organization of workshops and meetings with programme directors and the communication with the RDMA. Further educational support was available from the Dutch Advisory Board for Postgraduate Curriculum Development (DABCPD)[8] and the educational working group of the RDMA.

Competency-based education is inspired by social constructivism. This modern learning theory assumes that knowledge is individually and socially constructed. Individuals give their own meaning and interpretation to the things that happen in their environment, and this meaning and interpretation is also shaped by interaction with other people. In the context of curriculum development, this means that learning should be an engaging, constructive and active process that takes place in or is easily transferred to realistic practical situations[9].

The project team organised the development process of the new curriculum around the principles of systematic design. This design approach has its fundamentals in design methodology and has repeatedly proved successful in new product development (material products as well as intangible services). Systematic design intends to stimulate creativity while, at the same time, the controllability of the design process is increased significantly.

Modern systematic design embraces a large and diverse set of methods and approaches but can be characterised along four underlying principles[10]. The first principle, discursiveness, implies semi-structured guidance for the design process through a step-by-step yet iterative scheme of activities. Hierarchical decomposition refers to decomposing the design tasks into smaller, easier to handle but interdependent subtasks, setting up a so-called morphology for the design task. This step also includes the formulation of several design specifications for the whole design problem. These specifications are the requirements of the design. Systematic variation deals with the way of searching for solutions for subtasks and combining these following the morphological scheme into solutions for the complete design task. To prevent designers from endlessly searching for ever better solutions the principle of satisficing was introduced by Simon in 1969. According to this principle searching for an acceptable solution is by far superior to searching for an optimal solution[11]. Finally the solutions for the subtasks are combined into an overall solution and tested against the formulated design specifications.

Results

First, we present the features of the new curriculum and we explain how the (medical) knowledge of radiology, radiological procedures and radiology organisation, and the educational framework/toolbox of competency-based education are applied. Second, we present how we applied the principles of systematic design to the development process of the new curriculum. We provide a timeline of the development process and discuss unforeseen developments and delays the project team had to deal with during the process.

Features of the new curriculum

See Table 1 for the unique features of the new curriculum.

Organ based

The new curriculum is organ systems based (Table 2), with integration of radiological techniques within these organ systems (Table 3). This makes it possible to anticipate the more specialised knowledge about specific diseases needed for answering clinicians' questions.

Common trunk and subspecialisation

The common trunk encompasses a uniform national training programme on the basics of all organ systems (Table 2). The subspecialisation programme in the last 2 years of training focuses on one of eight subspecializations (Table 2).

There are a number of reasons to implement the common trunk and subspecialisation structure. First, the ETCC adopted this model. Second, this structure anticipates the rapidly growing knowledge base. It seems impossible to learn and keep up to date will all relevant knowledge in radiology. The total knowledge base is therefore divided into eight subspecialisations. This allows individual radiologists to become experts in and keep up to date with a specific subspecialisation, whilst the aggregated individual competencies in the team of radiologists comprise the total knowledge base needed. Third, the structure gives residents the motivational opportunity to distinguish themselves from their colleagues. Fourth, the new structure formalises and recognises expertise of different radiology

Table 1

Features of the new curriculum

- Organ based
- Uniform national three year common trunk, followed by a two year subspecialisation into one of eight directions
- Competency outcome based with appropriate assessment tools and techniques
- Based on regional collaboration among radiology departments, with exchange of residents between departments

Table 2

Organ systems modules & subspecialisations in the new curriculum

Organ systems module in the common trunk	Organ systems modules in the subspecialisation
Chest	Chest
Neuro	Neuro & Head and Neck
Head and Neck	
Musculoskeletal	Musculoskeletal
Cardiac	Cardiac
Gastrointestinal	Abdominal (Gastrointestinal, Urogenital & gynaecology)
Urogenital	
Paediatric	Paediatric
Breast	Breast
Interventional	Interventional

Table 3
Radiological techniques in the new curriculum

Conventional radiology
Ultrasound
Computed Tomography
Magnetic Resonance Imaging
Biopsies
Intervention
Nuclear diagnostics

Table 4
Competency levels in the new curriculum[13]

Level 1	Knowledge possession
Level 2	Performing with high supervision by radiologist
Level 3	Performing with moderate supervision by radiologist
Level 4	Performing without supervision by radiologist
Level 5	Supervising and educating during the performance

departments. Because of differences in patient populations and existing investments, radiology departments differ in the procedures they perform and the knowledge bases they possess. Departments can enhance their expertise by teaching the associated subspecialisation. Finally, the structure improves the match of supply and demand of labour. The inflow of radiology residents into subspecialisations can be adjusted to the number of radiologists with particular profiles required in the field. The resident can specialise in one subspecialisation or continue general radiology training in the last 2 years. Fifty per cent of the time in the last 2 years is devoted to the subspecialisation. The other 50% is devoted to general radiology. The subspecialisation is open to residents who perform above average. In addition to general and specialised radiology training, the new curriculum encourages residents to pursue scientific training. This consists of 1 day each week devoted to science, equalling 20% of total training time. This training option is open for residents who have conducted PhD research or are about to finish one.

Competency outcome based
Based on the seven CanMEDS core competencies, a specific competency profile for radiology was put together[12]. For example, the general competency "communication" was subdivided into communication with clinicians" and "communication with patients and family". Within "communication with clinicians", specific competencies such as "the resident reports relevant, accurate and explicit findings of radiological diagnostics timely" were formulated.

The organ systems comprise the themes, or basic building blocks, of the curriculum. For each organ system, competency levels (Table 4) were assigned for year one, year three and year five[13]. For year five, two competency levels were assigned for each subspecialisation; one competency level for residents who follow the specific subspecialisation and one competency level for residents who follow general training.

For each of the organ system modules, three entrustable professional activities (EPAs) were composed. These are information-rich activities which assist residents and radiologists in focusing educational attention[14]. CanMEDS competencies were attributed to each of the organ system modules and for each of the EPAs. For example, within the organ systems module "Cardiac", the EPA "patient with signs of angina pectoris as interpreted from the CT/MRI" was formulated.

Table 5
Assessment blueprint (instruments, accompanying competencies and frequency of use)

Assessment instrument	Competency	Frequency of use
Mini-Clinical Evaluation eXercise (Mini-CEX)	Medical expert, communicator, collaborator, scholar, manager, health advocate and professional	Ten observations each year (obligatory)
Multi-source feedback	Medical expert, communicator, collaborator, manager and professional	Once each year (not obligatory)
Objective Structured Assessment of Technical Skills (OSATS)	Medical expert, communicator and professional	Ten observations each year (not obligatory)
Critical Appraised Topic (CAT)	Medical expert, communicator and scholar	Twice each year (obligatory)
Progression tests	Medical expert, scholar and health advocate	Twice each year (obligatory)
Portfolio and periodical meetings with programme director	Medical expert, communicator, collaborator, scholar, manager, health advocate and professional	1st year: five meetings 2nd and 3rd year: three meetings 4th and 5th year: two meetings

The CanMEDS competency "collaboration" and "professional" were attributed to this EPA, because fast and efficient consultation with the cardiologist is required. In the new curriculum, multiple assessment instruments are being used (Table 5) to assess progress of the residents on the competency levels for the organ systems modules and the EPAs. Multiple assessment instruments are necessary to draw reliable and valid conclusions[15].

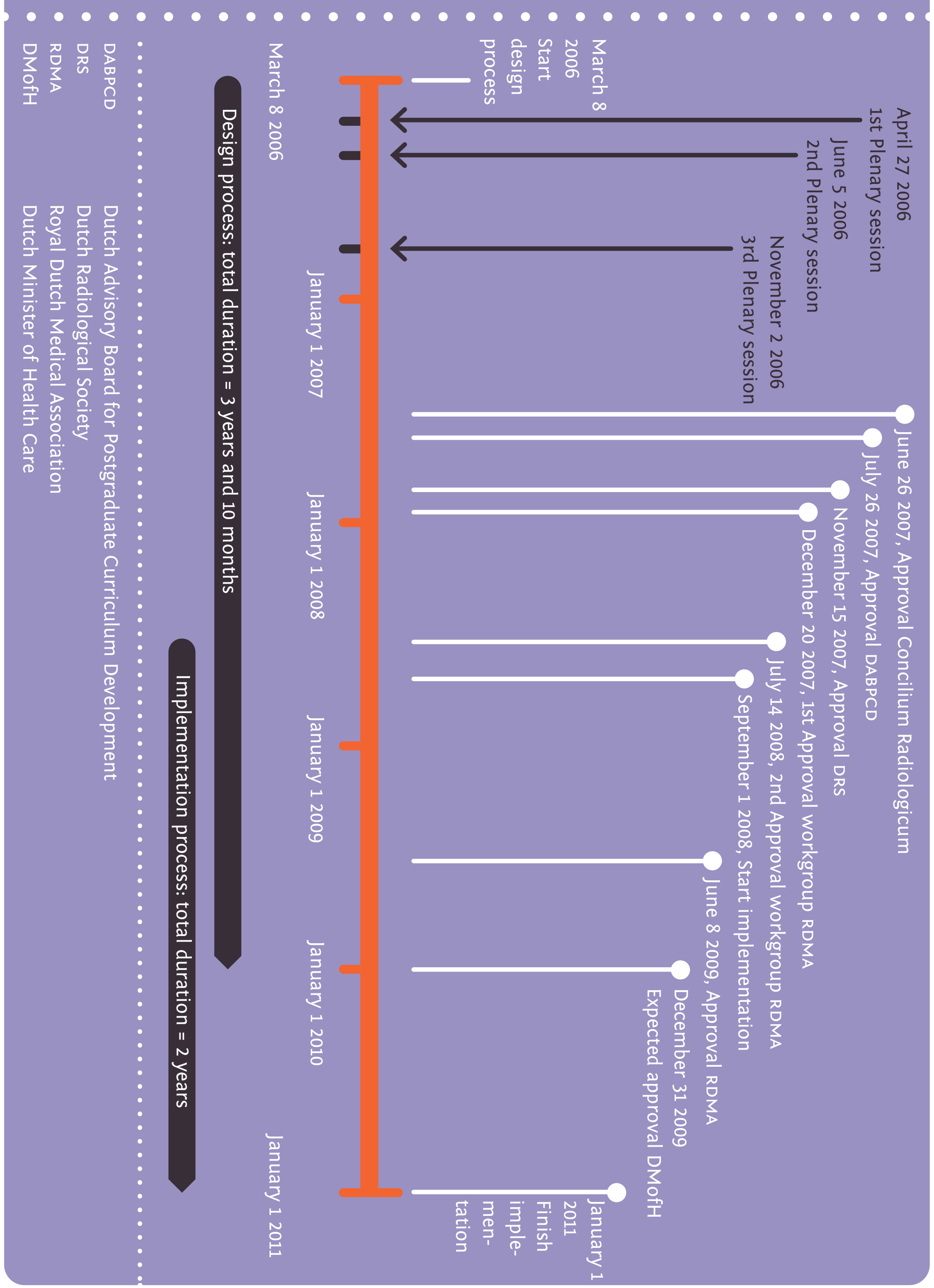
For each assessment instrument, competencies were assigned and frequency requisites formulated (Table 5). Assessment can be formative (guiding future learning, promoting reflection) or summative (making an overall judgement about competence, qualification for higher levels of responsibility)[15].

The assumptions of the assessment strategy of the new curriculum include:

- Assessment is mainly formative
- Summative assessment takes place at the end of each year of training
- Multiple observations in varying settings from different assessment instruments are necessary to make a summative judgement about overall competence
- Single observations from one assessment instrument are insufficient for sound judgement of competence
- The assessment instruments assess all competencies in every year of training
- Residents need to master the competencies on the required competency levels
- Premature termination of the training is possible when the assessment results indicate (persisting) disfunctioning on at least two competencies
- The team of supervising radiologists are responsible for the assessment
- Use of assessment instruments and providing feedback requires training for both the supervisors and the residents

The mini-CEX is a method of assessing competencies in real-life clinical practice. It consists of a short observation by a qualified medical specialist of a resident demonstrating clinical skills, using a predefined scoring format, in congruence with the competency profile of the radiologist, followed by a structured feedback conver-sation[16]. Assessment in the feedback conversation is formative. When

Figure 1
Timeline of the design and implementation process of the new curriculum



feedback is brought safely, timely, specific and well structured, this assessment can be a valuable mechanism of supervision and learning[17]. Multi-source feedback is a method of gaining feedback from multiple people with different functions in the radiology department[18]. This method is intended to be used as input for annual progress assessment interviews between resident and programme director. The objective structured assessment of technical skills (OSATS) is a method of assessing technical skills and is particularly suitable in the operation theatre[19], or, for radiology, in the intervention room. The critically appraised topic (CAT) consists of a systematic literature search on a specific structured clinical question[20]. A national knowledge progression test is being applied annually to demonstrate progress throughout the training period and allow group comparisons. In their portfolios, residents collect evidence about their personal development. Results of assessments are recorded, and evidence of acquired knowledge and skills is collected, including repeated reflection on acquired competencies, competency levels, and a personal strengths–weaknesses analysis[8]. The portfolio is reviewed in the annual progress assessment interviews.
All assessment instruments were adapted for use in radiology and after adaptation not assessed for validity and reliability. However, the psychometric properties of every single instrument was tested in other settings. Epstein provides an excellent overview of the properties of many assessment instruments[15]. For example, research has shown between seven and eleven different observations with the mini-CEX are necessary to achieve a generalizable global estimate of competence[15,21].

Regional collaboration
Historically, the entire radiology residency training was provided at a single medical centre. Although some radiology departments and hospitals made agreements on multi-centre training programmes and regional collaboration in education, this was not formalised in the national curriculum or legislation. The new curriculum recognizes that training can benefit from alternating training periods in both university and general hospitals, and from an active collaboration between centres in regional educational activities. The national curriculum and educational framework can be used in different ways in every region of medical education, but the exchange of residents within a region is mandatory. Furthermore, every region is required to make agreements on which subspecializations in the last 2 years of the curriculum they aspire to offer.

Table 6

Design specifications and accompanying discussion points for the new curriculum

Design specification	Discussion point
A new curriculum needs to be designed	No discussion
The new curriculum needs to encompass training periods in university and general hospitals	Some programme directors were concerned about reduction of autonomy due the training in both university and non-university hospitals
The exchange of residents between university and general hospitals needs to be organised within the eight regions of education in the Netherlands	Some programme directors were concerned about reduction of autonomy
The new curriculum needs to be competency-based and modularly designed	Some programme directors were not convinced of the advantages of competency-based education and were worried about the additional time for using the new instruments
The new curriculum needs to consists of a three year common trunk and two year subspecialisation	Some programme directors were afraid that insufficient radiologists with a general profile would be trained
The new curriculum needs to be organ-based	Some programme directors were concerned about the amount of time and energy necessary for organising the rooms, equipment, teams and ICT infrastructure differently

The development process of the new curriculum

Discursiveness

Figure 1 illustrates the design and implementation process. The design process was largely specified beforehand and divided into several design steps. The process was highly iterative. Because of developments in later phases prototypes were refined and improved.

Hierarchical decomposition

From the start of the project, the HORA project team realised that the support of the radiology programme directors was a prerequisite for the new curriculum to be accepted. For this reason, the HORA project team organised three plenary meetings (Figure 1) involving all programme directors. For the first plenary meeting, several design specifications of the new curriculum formulated by the HORA project team (see Table 6) were discussed with the programme directors, and agreed upon by all but one.

For the second plenary meeting, all programme directors were asked to discuss the specifications of the new curriculum within their region of medical education, and to come up with further specifications and discussion points for every specification. The second meeting made clear that all eight regions of medical education supported the specifications, and several useful discussion points were put forward (Table 6). For the third plenary meeting the HORA project team broke down the design task into smaller, but inter-dependent subtasks according to the guidelines provided by DABPCD and the working group RDMA (see Table 7 for the morphological scheme of the design task).

Systematic variation

For each subtask, several solutions were formulated (Table 7). For some subtasks the solutions were limited by legislation. For example, competency-based education was chosen by the RDMA as the teaching philosophy for all Dutch medical postgraduate training.

Satisficing

After the solutions were formulated, the HORA project team made a distinction between solutions that had to be solved in the short (within months), medium (within 3 years) and long term (within 5 years), and between decisions that ought to be made by the project team HORA or by other parties (see Table 7). The decisions that had

Table 7

Morphological chart: Subtasks and solutions in the new curriculum

Design task	Subtasks	Possible solutions	Time period of decisions	Primary responsibility	Solution
Design of new curriculum radiology	Profession analysis / radiology specific profile	The general CanMEDS framework*, the European Training Charter[4] and the *Good Practice Guide For European Radiologists*[12]	Short	Project team HORA	For each competency several radiology specific subcompetencies were formulated
	Themes / building blocks	The organ based systems provided by the European Training Charter[4]	Short	Project team HORA	See Table 2 (left side)
	Assessment strategy and instruments	Assessment strategy can be formative (oriented towards formulating learning points) or summative (making a judgement about competence). Many assessment methods are possible[20]. For example: • Multiple choice questions / progression test • Essay • Short answer question • Oral exam • Objective structured clinical axamination • In-training evaluation report (e.g. mini-CEX) • Multi-source feedback • Critical appraised topic • Portfolios and logbooks	Short	Project team HORA	See Table 5
	Teaching philosophy	Competency based education*	Short	Project team HORA	Competency based education
	Teaching activities	Many teaching activities are possible. For example: • Patient reporting • Radiological workstation • Cursory conferences • Journal clubs • Critical appraised topic • Teaching round • Outpatient clinic • Patient round • Intervention room / operating room • Consultations • Mortality/morbidity review • Multidisciplinary conferences • Structured series of conferences	Short	Project team HORA	• Radiological workstation • Consultations • Multidisciplinary conferences • Cursory conferences • Structured series of conferences • Critical appraised topic / “holy hour” • Intervention room / Operating room

*Mandatory by the RDMA, possible solutions were limited

continuation on page 60

Table 7 *continuation (1)*

Morphological chart: Subtasks and solutions in the new curriculum

Design task	Subtasks	Possible solutions		Time period of decisions	Primary responsibility	Solution
Design of new curriculum radiology	Teaching materials	Many teaching materials are possible and need to be made. For example: • Curriculum / training programme • Assessment instruments • Course materials • Guidelines / protocols • Literature		Short and medium	Project team HORA for the short term and the regions of medical education for the medium term	The curriculum was written with chapters corresponding to the subtasks in this table. Teaching materials for the assessment instruments were developed (see Table 5). Other teaching materials were or have to be developed by the regions of medical education
	Training / curriculum structure	Curriculum structure Possible solutions: • General training • Subspecialised training • Combination of general training and subspecialised training		Short	Project team HORA	3 year common trunk and 2 year subspecialisation. In the subspecialisation phase 50% of the time is devoted to general radiology and 50% to the chosen subspecialisation
		Collaboration with other radiology departments for the exchange of residents	Collaboration with radiology departments within a region of medical education or between regions of education	Short	Project team HORA	Collaboration and exchange of residents takes place among the radiology departments within the regions of education. Exceptions can be made for individual residents
			Duration of exchange periods; between six months and four years	Short	Project team HORA	Minimum of one year
			Possibility of unconnected exchange periods; e.g. two periods of six months	Short	Project team HORA	The exchange can be unconnected
			Year of training in which the exchange has to occur; year one to year five	Medium	Region of medical education	Variable

continuation on page 62

Table 7 *continuation (2)*

Morphological chart: Subtasks and solutions in the new curriculum

Design task	Subtasks	Possible solutions		Time period of decisions	Primary responsibility	Solution
Design of new curriculum radiology		Collaboration with other radiology departments for the exchange of residents	Labour law and appointments; separate appointments for every hospital or one appointment with the hospital in which the main part of training is followed	Medium	Region of medical education	Variable, predominantly by one appointment
			Financing of residents; by the hospital in which the resident follows the training at the time or by the hospital in which the residents follows the main part of training	Medium	Region of medical education	Variable, predominantly by the hospitals in which the resident follows the main part of training
	Quality monitoring	Requirements for hospitals to offer the common trunk and to offer subspecialisations		Long	National subspecialisations sections for radiology specific requirements. RDMA for more general requirements	Formulated for every subspecialisation
		Requirements for individual supervisors		Long	RDMA	Formulated for all medical specialists
		Quality control mechanisms to monitor curriculum implementation. Possible mechanisms include: • New project team to coordinate and monitor the curriculum implementation • Periodical reporting by programme directors • Official and non-official quality audits / site visits by independent observers • Questionnaire to programme directors, radiologists and residents		Medium	Project team HORA / Concilum Radiologicum	HORA 2 project team was installed to monitor the implementation of the new curriculum. The project team consists of one representative of every region of education and one educationalist. Further mechanisms which are used include: • Official quality audits / site visits • Periodical reporting by the representative of every region of education • Digital questionnaire to all radiologists and residents

to be made in the short term were prepared by the HORA project team and discussed in the third plenary meeting with all programme directors. Agreement could be reached on all short-term decisions (see Table 7). Many decisions were delegated to the regions of medical education to allow for optimal alignment to the local context, and to avoid information overload of the HORA project team. For each subspecialisation, a dedicated section of DRS members formulated quality criteria for the radiology department offering subspecialisations, along with an approval procedure for radiology departments, and a registration system for residents and radiologists who successfully complete a subspecialisation training programme. Finally the total design of the curriculum (Table 7) needs to be tested against the design specifications (Table 6). All design specifications were met.

Unforeseen developments and approvals

After the three plenary sessions, the curriculum was completed pending approval by several authorities (Figure 1). After approval by the Concilium Radiologicum, the curriculum was evaluated and approved by the DABPCD. The DRS approved the new curriculum in a general members meeting. Before formally approving the new curriculum, the RDMA decided to introduce their own educational advisory group (working group RDMA) to give educational approval. Although this working group approved the curriculum this caused a 1-year delay. Subsequently, the curriculum had to be formally approved by the RDMA. Because of a high workload (other medical specialties were also completing their new curricula), the RDMA approval procedure caused another 1-year delay.

The final step was approval by the Dutch Minister of Healthcare. To avoid further delay, the working group RDMA advised the HORA project to start implementation in September 2008, whilst formal approval of the RDMA and the Dutch Minister of Healthcare was still pending. For this reason, the development and implementation process overlapped for about 15 months. The RDMA approved the curriculum in June 2009.

Discussion

We have described the development procedure and main components of the new radiology curriculum in the Netherlands. Only when the new curriculum has been in use for a number of years will we be able to reflect on the components of the curriculum and its impact on the performance of young radiologists and the organisation of radiology departments. Here, therefore, we will discuss the systematic development process. The highly dynamic and non-linear development process was influenced by many stakeholders, developments and unforeseen factors. Although this is the rule rather than the exception in such innovation and change projects[22], it is possible to discuss the usefulness of the systematic design procedures, and to identify success factors in this project of complex change.

Discursiveness

The design process was largely specified beforehand in a logical step-by-step iterative approach. The specification beforehand proved valuable because it was clear to everyone what steps needed to be taken and which results needed to be achieved for particular meetings. Another strength of the discursiveness principle is that unforeseen developments can be incorporated. This seemed useful, especially during the curriculum approval phase. Despite the 2-year delay caused by an additional approval step and the high workload of the regulatory authorities, these steps significantly improved the quality of the curriculum.

Hierarchical decomposition

The HORA project team broke down the overall design problem into several subtasks. For the overall design six design specifications were formulated, and these were discussed with the programme directors. These steps proved extremely useful. First, it made the complex design task easier. Second, involving the programme directors from the start of the process in deciding on the specifications of the new curriculum made them responsible for the ultimate results and prevented them from re-discussing the specifications and the necessity of curriculum change in a later phase.

Systematic variation

The HORA project team, the regions of medical education, and the programme directors came up with several solutions for the subtasks, which allowed for an efficient division of tasks among individual members and subgroups, avoided information overload and involved the relevant stakeholders.

Satisficing

Making a distinction between short-, medium and long-term decisions helped to focus the debate on decisions that needed to be taken at a specific moment in time. By outsourcing and decentralising some decisions, people were able to adapt these to local circumstances, and information overload of the HORA project team was avoided. It has been shown that innovations are adopted better and more quickly when adopters can tailor the innovations to their own needs[23].

Overall, the use of systematic design principles to structure the development process proved highly valuable. They led to a structured, yet flexible, development process in which creative solutions could be generated and adopters (programme directors, supervisors and residents) were highly involved. This is a prerequisite for the adoption and successful implementation of the new curriculum.

Strengths, limitations and suggestions for further research

The description of the design (content) of the new curriculum, as well as the development process, adds to the existing knowledge base and could be useful for scientific communities of radiology and programme directors who are about to start or are currently busy with designing a new curriculum. Several papers have appeared on curriculum design and evaluation of the CanMEDS framework within medical education[24-28] and radiology[29], but the integral description of the design and of the development process according to evidence-based systematic design principles has not been documented before.

There are some limitations. First, the paper lacks empirical data on the implementation and ultimately the effectiveness of the design of the curriculum and the application of design principles. It would be interesting to empirically test the implementation and the effectiveness of the subtasks of the design (Table 7), for example the organ systems-based modules (Does it improve the quality of radiological service? What is the influence on the quantity of requests for radiological research? Is there any change in the subjective perception of the radiologists of their jobs? What is the influence on effective manpower management?). It would also be interesting to empirically test the importance of every principle in such complex innovation processes. Second, the paper is limited to the Netherlands. Because of differences in patient populations and the organisation of radiology departments the curriculum probably needs some adjustments before it can be implemented in other countries.

Conclusions

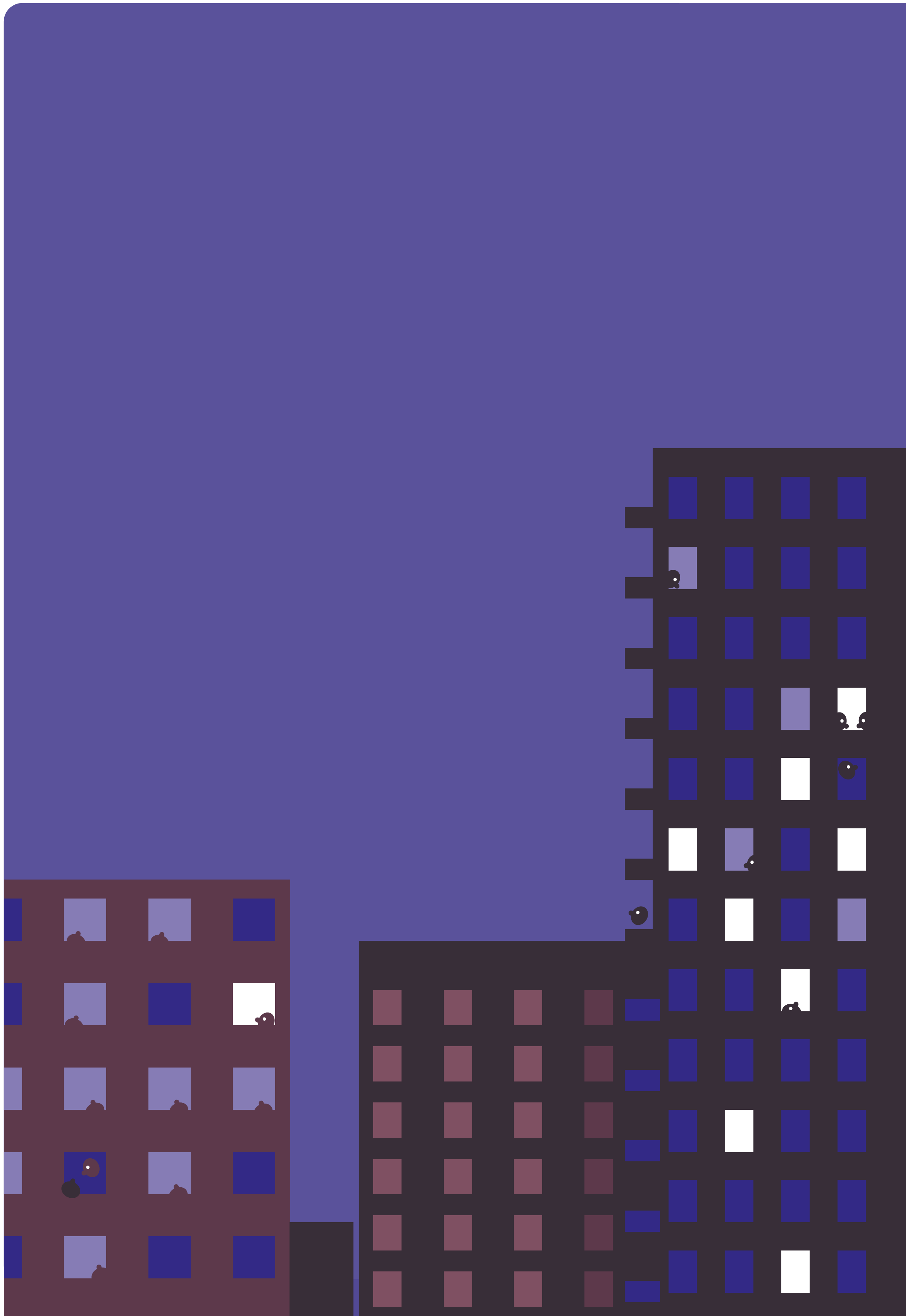
The HORA project team incorporated many complex developments and succeeded in producing an exciting new radiology curriculum in the Netherlands. This curriculum is necessary for the future of radiology in the Netherlands, providing not only high quality training for radiology residents, but also advancing the science of radiology in the next few decades. The use of the systematic design principles proved useful in the development process of the new curriculum. The next challenge is to implement the curriculum in everyday practice.

Acknowledgements

We would to like thank the participants of the HORA project (J.C.N.M. Aarts MD, H.J. Baarslag MD PhD, E. Coerkamp MD, O.M. van Delden MD PhD, M.W. de Haan MD PhD, M. Heitbrink MD, F.B.M. Joosten MD PhD, S.P. Kerssemakers MD, P.N.M. Lohle MD PhD, A.K. Meininger MSc, R.B. Rouw MD, A.Tielbeek MD PhD) and the programme directors for their support and advice during the development process of the new curriculum.

References

1. CanMEDS 2000: Extract from the CanMEDS 2000 project societal needs working group report. *Med Teach*. 2000;22:549-54.
2. Board of Health Care Professions and Education in the Netherlands. *www.cbog.nl. Accessed June 5th 2009.*
3. Blijham GH, Mens MAP. *OOR-zaak en gevolg, Nederlandse Federatie van Universitair Medische Centra visie-document (cause and effect, Dutch Federation of University Medical Centers vision-statement)*. Badoux drukkerij BV; 2005.
4. European Association of Radiology. *Detailed curriculum for the initial structured common programme, detailed curriculum for subspeciality training.* Vienna: EAR; 2005.
5. HORA Project Team. *Herziening opleiding radiologie (HORA) (revision of radiology curriclum). http://knmg.artsennet.nl/artikel/Radiologie-3.htm. Accessed June 5th 2009.*
6. Dalla Palma L. Tomorrow's radiologist: What future? *Radiol Med*. 2006; 111:621-33.
7. Matin B, Bates DW, Sussman A, Ross P, Hanson R, Khorasani R. Inpatient radiology utilization: Trends over the past decade. *Am J Roentgenol*. 2006; 186:7-11.
8. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach.* 2008;30:248-53.
9. Dochy F, Heyen L, Mosselaer H. *Assessment in onderwijs (assessment in education)*. Utrecht: Lemma; 2002.
10. Leenders RTAJ, van Engelen JML, Kratzer J. Systematic design methods and the creative performance of new product teams: Do they contradict or complement each other? *J Prod Inn Man*. 2007;24:166-79.
11. Simon HA. *The sciences of the artificial*. MA: MIT Press; 1969.
12. European Society of Radiology. *Good practice guide for european radiologists.* Vienna: ESR; 2007.
13. Miller GE. The assessment of clinical skills, competence and performance. *Acad Med*. 1990;65:S63-7.
14. Ten Cate O. Entrustability of professional activities and competency-based training. *Med Educ*. 2005;39:1176-7.
15. Epstein R. Assessment in medical education. *N Engl J Med*. 2007;356:387-96.
16. Norcini J, Blank L, Duffy FD, Fortna G. The mini-CEX: A method for assessing clinical skills. *Ann Intern Med*. 2003;138:476-81.
17. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication*. Oxford: Oxford University Press; 2003.
18. Violato C, Lockyer JM, Fidler H. Changes in performance: A 5-year longitudinal study of participants in a multi-source feedback programme. *Med Educ*. 2008;42:1007-13.
19. Wilkinson JR, Crossley JG, Wragg A, Mills P, Cowan G, Wade W. Implementing workplace-based assessment across the medical specialties in the United Kingdom. *Med Educ.* 2008;42:364-73.
20. Bandiera G, Sherbino J, Frank J. *The CanMEDS assessment tools handbook: An introductory guide to assessment methods for the CanMEDS competencies.* Ottawa: Royal College of Physicians and Surgeons of Canada; 2006.
21. Alves DL, Barrero C, Baratta S, Castillo Costa Y, Bortman G, Carabajales J, et al. Validity, reliability, feasibility and satisfaction of the mini-clinical evaluation exercise (mini-CEX) for cardiology residency training. *Med Teach*. 2007;29:785-90.
22. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
23. Rogers EM. *Diffusion of innovations*. New York: Free Press; 2003.
24. Chou S, Cole G, McLaughlin K, Lochyer J. CanMEDS evaluation in Canadian postgraduate training programmes: Tools used and programme director satisfaction. *Med Educ*. 2008;42:879-86.
25. Mickelson JJ, Macneily AE. Translational education: Tools for implementing the CanMEDS competencies in Canadian urology residency training. *Can Urol Ass J*. 2008;2:395-404.
26. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach*. 2007;29:642-7.
27. Freiman A, Natsheh A, Barankin B, Shear N. Dermatology postgraduate training in Canada: CanMEDS competencies. *Dermatol Online J*. 2006;12:6-.
28. Ringsted C, Hansen T, Davis D, Scherpbier A. Are some of the challenging aspects of the CanMEDS roles valid outside Canada? *Med Educ.* 2006;40:807-15.
29. Baerlocher M, Asch M. The interventional radiologist as "clinician": What does it mean? CanMEDS for the interventional radiologist. *Can Assoc Radiol J.* 2006;57:25-9.



Chapter 3

Facilitators and barriers to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study

Erik Jippes
Scheltus J. van Luijk
Jan Pols
Marjolein C Achterkamp
Jo M.L. van Engelen
Paul L.P. Brand

Medical Teacher in press

Abstract

Background: Postgraduate Medical Education (PGME) curricula are being redesigned across the western world.

Aims: This study examined the implementation process (what works where and why) of new competency-based PGME curricula and relevant factors influencing this process.

Method: In a nationwide project (2006-2010) in the Netherlands, competency-based PGME curricula were implemented for residents in Pediatrics and Obstetrics & Gynecology. The authors conducted 25 semi-structured interviews and used a multi-level theoretical framework to guide coding.

Results: The implementation process proved to be highly dynamic, non-linear and influenced by many factors. These could be divided into attributes of the innovations/adopters, the implementation process, and the organization. The context determined the speed, quality, direction of the process and how a factor affected the process.

Conclusions: We identified specific features of PGME innovation: the challenge of implementing other competencies than that of the medical expert; the importance of regional implementation strategies and educational support; the balance between training and patient care; and the need for regional inter-organizational networks of hospitals. The authors recommend: design the curriculum with the needs of the users in mind; facilitate knowledge sharing; organize educational support; translate the national curriculum to the local workplace; and promote regional inter-organizational networks between hospitals.

Keywords: Curriculum implementation, Medical education, Qualitative research

Table 1

Changes introduced into Dutch PGME curricula

The Royal Dutch Medical Association (RDMA) introduced in 2004 the following changes into PGME in the Netherlands:

- The CanMEDS framework. The entire curriculum, including the learning goals, building blocks, assessment strategy and instruments, teaching activities and materials should be oriented to a set of seven roles for practicing specialists, derived from societal needs:
  - Medical expert
  - Communicator
  - Health advocate
  - Collaborator
  - Manager
  - Scholar
  - Professional
- The Mini Clinical Evaluation eXercise (Mini-CEX), frequency 10 observations each year:
  - Method to assess competencies in real life clinical practice[22]
  - Consists of a short observation by a qualified medical specialist of a resident demonstrating clinical skills, using a pre-defined scoring format, followed by a structured feedback conversation[21]
- The portfolio, including periodical interviews between the program director and residents about the portflio, frequency 1st year five meetings, 2nd and 3rd year three meetings, 4th and 5th year two meetings:
  - In the portfolio, residents collect evidence documenting personal development according to the CanMEDS roles
  - The results from the assessment instruments and evidence of acquired knowledge and skills are assembled, along with results of repeated reflection sessions on acquired competencies and a personal strengths-weaknesses analysis[5]
- The Critical Appraised Topic (CAT), this includes the systematic search of scientific evidence for a clinically relevant question, frequency twice each year
- Knowledge progression tests, frequency each year

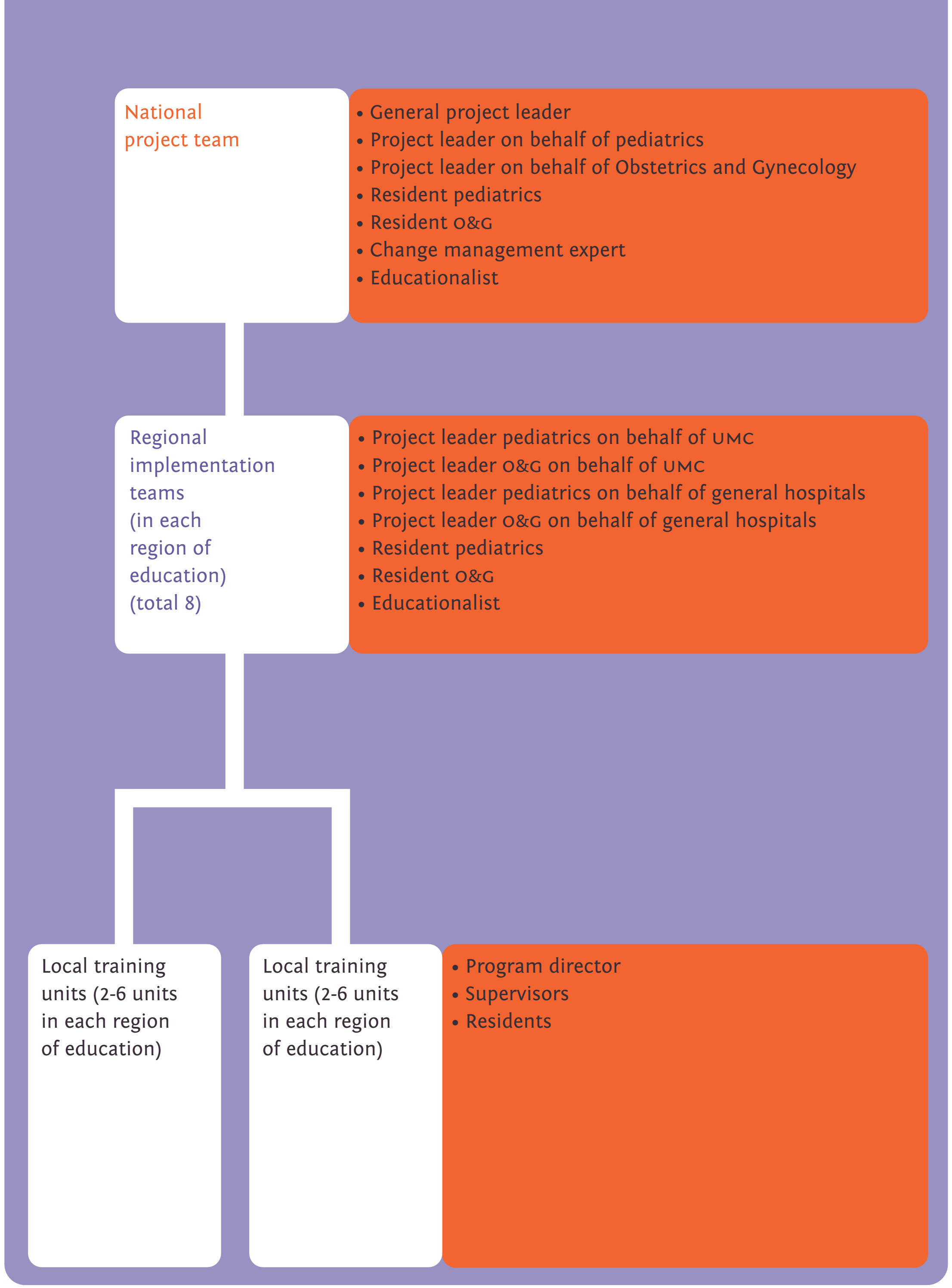
Introduction

In the last decade, postgraduate medical education (PGME) programs are being redesigned across the western world. Teaching philosophies that were already being used for a long time in undergraduate medical education have now been embraced by policymakers of postgraduate medical education programs as well. Generally speaking, these philosophies concern outcomes-based education. This is a learner-oriented philosophy that focuses on the learner performance, or outcomes, instead of the resources available to students, or inputs. One approach to outcomes-based education which has become popular in medical education in the western world is competency-based education[1]. This can be defined "as an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies"[2]. In the context of medical education, a competency can be defined as "an observable ability of a health professional, integrating multiple components such as knowledge, skills, values and attitudes"[2]. In the United States, the Accreditation Council for Graduate Medical Education (ACGME) started the Outcome Project in 1998, to develop and implement general competency areas in all PGME curricula[3]. Another popular approach towards competency-based education is the Canadian Medical Education Directions for Specialists (CanMEDS) framework[4], which has been used as a basis for reforming PGME curricula in Canada, Australia, and in several countries in Europe.

Although it is universally agreed that implementation of competency-based PGME curricula involves major challenges[5,6-10], the implementation process and the factors influencing it have received little attention[11]. In Denmark, the renewal of PGME curricula has been documented. While stakeholders were positive towards the task of developing new curricula, they found this task quite difficult and gained insufficient support during the process[11]. Despite these interesting findings, the Danish study lacked an underlying theoretical framework, and the clinicians responsible for implementing and using the PGME curricula in practice, were not interviewed.
The Royal Dutch Medical Association (RDMA) adopted the CanMEDS framework in 2004 for all PGME curricula in the Netherlands. Every medical scientific society in the Netherlands was requested to design a competency-based PGME curriculum according to the seven roles and the required assessment instruments (see Table 1)[12].

Figure 1

Organization of the In vivo implementation process



From 2006 to 2010, as a pilot implementation project for all medical specialties, the revised competency-based PGME curricula for Obstetrics & Gynecology (O&G) and Pediatrics were the first to be implemented in the Netherlands through a nationwide project called "In vivo." Supported by a national project team (national level), the implementation process was guided by dedicated regional implementation teams in each of the country's eight teaching and training regions (regional level). Residents – medical specialists in training – in the O&G and Pediatrics programs follow their training in a teaching and training region, these consist of university medical centers and general hospitals, which collaborate in providing PGME. Program directors in approximately 70 training units were responsible for the implementation of the new curriculum in their departments (local level). Figure 1 presents the organization of the In vivo implementation process.

One of the major conclusions of an extensive literature review into diffusion of complex innovation in health service organizations was that the current literature lacks in-depth empirical assessments and descriptions of complex implementation processes in health care[13-15]. Other reviews confirmed the need for a research shift from "what works", to "what works where and why"[16].

We believe that the In vivo project can be viewed as a complex implementation process[16]. Many stakeholders with different backgrounds were involved, including health care professionals, educationalists, medical scientific societies, the government, the RDMA, and the hospitals. The implementation concerned two different medical specialties and different levels (nationwide, regional and local) of organizing the implementation process. Finally, the implementation of PGME was closely connected to health care processes, because residents learn while working as a medical doctor in the hospitals. Implementation of a renewed PGME curriculum therefore requires changes in the way health care processes are structured and vice versa, increasing the complexity of the process[16].

To understand the implementation of a competency-based PGME curriculum and to provide recommendations for health care professionals and policymakers to tailor their interventions in these complex implementation processes, we conducted a qualitative study evaluating the process in the In vivo project. A qualitative approach was chosen in order to allow a detailed and context-rich description of the complex implementation process at the national, regional, and local levels, along with a description of the factors influencing this process. Our research question was: Which conditions promoted and impeded for what reason the implementation process on the different levels of the project?

Methods

Over a six-month period in 2010, we conducted 25 semi-structured, in-depth interviews with participants from the national, regional, and local levels of the project. The respondents were strongly encouraged to state their opinions freely and comprehensively. Theoretical sampling was used to select the respondents[17]. The sampling procedure and the interview topics are listed in Table 2.

Established ethical standards were used to guide the research procedure[18,19]. All participants gave informed consent. All interviews were recorded and transcribed verbatim (with participants identified by their roles). We used directed content analysis to analyze the interview texts[20]. In contrast to grounded theory approaches, in which the coding schemes are developed during or after data collection, directed content analysis uses a theory-based coding scheme that is constructed before data collection. Directed content analysis is considered appropriate when useful theoretical models are available and the purpose of the study is leaning more towards application of existing theory and less to building new theory. To guide the coding of interview data and to report our results, we used a multi-level theoretical framework of complex innovation in health services organizations, constructed by Greenhalgh and colleagues. This framework is the result of the most extensive systematic review currently available in the field of complex innovation in health care. After searching 6000 sources from different research traditions, nearly 500 sources of empirical evidence were included[13-15].

The first two interviews were coded independently by four researchers, and differences in the coding scheme were resolved by discussion and consensus. Subsequent interviews were coded independently by two of these researchers, and all differences in coding interpretation were resolved in the same manner. The principal investigator used these codes to construct a framework describing the implementation process and the factors influencing it. The quotations and the procedure revealed a highly consistent pattern of factors influencing the implementation process. After a group discussion, the final framework was approved by all authors[20].

Results

Following from the directed content analysis, the factors influencing the implementation process of the PGME curricula found in this study were divided into three categories: attributes of the innovations and adopters, attributes of the implementation process, and attributes of the organization[13]. In the following section, we address these factors and we discuss in more detail whether these factors had an impeding (barrier) or promoting (facilitator) effect in the project (see Table 3).

Attributes of the innovation and adopters

The interviewed subjects identified the following (sub-)innovations as the four most important: the explicit use of the CanMEDS roles (see Table 1), a behavioral change of supervisors (structured feedback) and residents (pro-active attitude), the introduction of new assessment instruments, and the modified and more explicit structure of local training programs. We report the (sub)innovations in terms of their relative advantage, their simplicity and their compatibility with values, norms and needs of the adopters.

Relative advantage

Although they did acknowledge that the new curriculum prompted more attention to competencies other than medical skills, respondents also expressed the view that the intended full operationalization, implementation and assessment of all of the CanMEDS roles was only in its initial stage. Reasons included the abstract nature of competencies (e.g., health advocacy[7]), a tendency to focus on easily assessable competencies, lack of time and lack of training.
SV (PD = program director, SV = supervising medical specialist, RE = resident, NPT = national project team): I think that it's more an impression of whether all of these factors are decisive, or whether a person appears somewhat professional … It's not just in boxes of "Okay, this, this, this, and then" – all seven competencies in a row – it just doesn't work that way.

Skeptical adopters also mentioned the lack of evidence for the CanMEDS roles. The adopters' perception of the quality and validity of the evidence supporting the innovation can influence their adoption decision[16].
PD: But I keep wondering who has actually proved that this really does make things better. Is this really a positive innovation, or could it cause problems for us in five or ten years?

Table 2
Sampling procedure and interview questions

	Goal	Respondents	Interview topics/questions
National level	• Gain overall view of the project • Gain insight into effects of national and regional implementation strategies and processes, and the factors influencing them • Investigate different implementation strategies and regional implementation teams	Interviews with members of national project team (n = 3): • Project leader • Educationalist • Researcher	• What were the goals and results of the project? • Was the project structure effective in achieving the goals and results? • What factors positively and negatively influenced the implementation process? • What were the differences between regions in terms of the implementation strategy?
Regional level	• Gain insight into effects of national and regional implementation strategies and processes and the factors influencing them • Investigate whether some program directors and departments in the region were more innovative and active in the project	Interviews with members of two regional implementation teams (n = 10): • Project leader in Obstetrics & Gynecology • Project leader in Pediatrics • Two residents • Educational specialist Regional Implementation Team A: • Highly structured regional implementation process; regional implementation meetings were organized with all program directors in the region • Located in low-density population of people and hospitals Regional Implementation Team B: • Weakly structured regional implementation process; no structural regional implementation activities were executed • Located in a dense population of people and hospitals	• What were the goals and results of the project? • What was the implementation strategy in your region? • What factors positively and negatively influenced the implementation process? • What are the main differences between before and after the project? • How has the project contributed to these differences? • Were there differences between the departments in your region with regard to innovation and activity?

continuation on page 82

Table 2 *continuation*
Sampling procedure and interview questions

	Goal	Respondents	Interview topics/questions
Local level	Gain insight into effects of regional and local implementation strategies and processes and the factors influencing them	Interviews with members of two departments in the two regions (Departments A and B) (n = 12): • Program director • Supervisor • Resident The two departments differed in their innovation and activity with regard to the regional implementation team and project	• What were the goals and results of the project? • What was the implementation strategy in your department? • How do you perceive the new curriculum and assessment instruments? • What are the main differences between before and after the project? • How has the project contributed to these differences? • What factors positively and negatively influenced the implementation process?

Table 3
Main attributes found to be important for PGME innovation

	Facilitator to implementation	Barrier to implementation
Attributes of the innovation and adopters		
Relative advantage of:		
*CanMEDS roles**	**What and why it worked as a facilitator:** The adopters attached some advantages to the use of this innovation. More attention to generic competencies in the assessment of residents was expected to have positive impacts on the improvement of health care quality and processes, like patient safety, collaboration and communication and organization. Furthermore the use of the CanMEDS roles provided a language between program directors, supervisors and residents to discuss the progress of the residents.	**What and why it worked as a barrier:** The program directors, supervisors and residents attached clear disadvantages to the use of this innovation: The CanMEDS roles proved difficult to operationalize, to implement and to assess – especially the non-medical competencies - in workplace-based training. This was caused by the abstract nature of competencies, a tendency to focus on easily assessable competencies,lack of time, lack of training and lack of evidence.
*Behavioral changes supervisor: Structured feedback**	**What and why it worked as a facilitator:** The program directors, supervisors and residents attached clear advantages to the use of this innovation. More structured feedback led to more balanced (both positive and negative comments), efficient and effective feedback encounters between supervisor and resident.	**What and why it worked as a barrier:** The program directors, supervisors and residents attached some disadvantages to the use of this innovation. Giving and receiving feedback was perceived as difficult: there was fear of damaging the relationship and fear of negative feedback. Also the quality of feedback by supervisors was sometimes perceived as worrisome by residents.
*Behavioral changes resident: Pro-active attitude**	**What and why it worked as a facilitator:** The adopters attached clear advantages to the use of this innovation. The residents became more aware of their learning objectives.	**What and why it worked as a barrier:** The residents attached some disadvantages to the use of this innovation. The residents felt sometimes disappointed because their learning objectives could not be accommodated due to the complexity of work schedules. Some supervisors considered the learning goals far too specific.
*Assessment instruments**	**What and why it worked as a facilitator:** The adopters attached some advantages to the use of these innovations. The use of the Mini-CEX produced an improved, standardized, and more objective assessment of clinical skills that allowed more explicit, focused, and balanced reflection on the clinical behavior of residents in specific situations. The portfolio enhanced the opportunity of residents to reflect on their own development and to construct their own training.	**What and why it worked as a barrier:** The program directors, supervisors and residents attached some disadvantages to the use of this innovation. The accomplishment of a certain number of assessments did become a goal in itself, although it should be a means to facilitate feedback. Organizing a Mini-CEX took a considerable time and effort. The potential of the portfolio was limited due the subjective nature and the limitations of the residents' ability to shape their own training.

*Specific feature of PGME innovation within the Greenhalgh framework, as described in the discussion section of this paper.

continuation on page 86

Table 3 *continuation (1)*
Main attributes found to be important for PGME innovation

	Facilitator to implementation	Barrier to implementation
Attributes of the innovation and adopters		
Relative advantage of:		
*Changes educational program**	**What and why it worked as a facilitator:** The adopters attached some advantages to the use of this innovation. More continuity in the internships led to more opportunities of supervisors to observer esidents and it lead to steeper learning curves of the resident.	**What and why it worked as a barrier:** The program directors, supervisors and residents attached some disadvantages to the use of this innovation. Implementation was sometimes difficult due to understaffing of supervisors and residents.
Simplicity and compatibility	**What and why it worked as a facilitator:** The innovations "structured feedback by supervisor" and "pro-active attitude resident" were fairly simple to comprehend and they were compatible with the values, norms, and perceived needs of the adopters. These innovations were easily implemented because relatively few additional resources were required to implement them in the work-based training.	**What and why it worked as a barrier:** The innovations "assessment instruments", "changes educational program" and "CanMEDS roles" were fairly difficult to comprehend and they were not so compatible with the values, norms and perceived needs. These innovations were less likely to be implemented because hey required a lot of effort to organize and implement and they intervened with daily health care processes.
Attributes of the implementation process		
External developments	**What and why it worked as a facilitator:** The forces that were outside of control of the national project were made work for the implementation process, rather than allowing them to work against the process. The increased attention to educational quality allowed the national project team to start pilot projects introducing an educational quality care system into PGME.	**What and why it worked as a barrier:** Allowing the forces that were outside of control of the national project to work against the implementation process. The introduction of a national medical training fund generated skepticism among the program directors, as it remained unclear how the quality was supposed to be measured. This had a negative impact on the implementation process, because adopters associated this process with the allocation of governmental funds and it consumed a lot of valuable time. The reduction in the number of pediatrics training positions during the project decreased motivation and increased the workloads of supervisors and residents, thus allowing less time for the implementation of the innovations.
Appropriate change model	**What and why it worked as a facilitator:** "Letting it happen" was facilitated by the national project team by stimulating regional implementation teams and program directors to entrepreneurship. Entrepreneurship caused regional implementation teams and program directors to take creative action and to let them feel responsible for the implementation process.	**What and why it worked as a barrier:** Too little "making it happen" by the national project team. The program directors, supervisors and residents perceived that they received too little guidance on the implementation process from the national project team in the beginning of the project. The adopters felt that they were turned loose and that is was unclear what was expected. This slowed down the process.

*Specific feature of PGME innovation within the Greenhalgh framework, as described in the discussion section of this paper.

continuation on page 88

Table 3 *continuation (2)*

Main attributes found to be important for PGME innovation

	Facilitator to implementation	Barrier to implementation
Attributes of the implementation process		
Good project management	**What and why it worked as a facilitator:** The flexibility in the project management by the national project team: The absence of objectives to be reached at certain points in time. The organic implementation process allowed for the incorporation of relevant developments. This increased the acceptance among the adopters because they perceived as having control over the process.	**What and why it worked as a barrier:** The absence of explicit goals, a clear time frame, and monitoring of the results by the national project team. The adopters felt that they were turned loose and that it was unclear what was expected.
*National and regional implementation strategies and activities**	**What and why it worked as a facilitator:** Well-organized national and regional meetings / activities with clear goals and relatively high returns for their time investment. Such meetings and activities generated knowledge sharing and a mutual understanding of the process.	**What and why it worked as a barrier:** The absence of or poorly organized national and regional meetings / activities. The absence of such meetings slowed down the implementation process because opportunities to share knowledge were missed. Poorly organized meetings left adopters frustrated because they experienced relatively low returns for their time investment.
*Educational support**	**What and why it worked as a facilitator:** The presence of well-organized educational support and competent educationalists. Educational support and educationalists significantly accelerated the implementation process by their specific expertise and knowledge, by providing concrete instructions for the use of the assessment instruments, by helping to translate the national curriculum to workplace-based training, by organizing the process, by assisting in setting up regional meetings and activities and by exchanging best-practices with their colleagues in other hospitals and regions. This support and expertise complemented the expertise of the busy physicians.	**What and why it worked as a barrier:** The absence of well-organized educational support and competent educationalists. The absence slowed down the implementation process. It meant that all support for the implementation process had to be delivered by busy physicians who are in general not trained in educational and change management issues.
Human resource factors: Training	**What and why it worked as a facilitator:** The provision in the early phases of the implementation process of well-organized training preferably for all adopters in a department aimed at implementing the innovations. Training generated a more positive attitude toward the innovations, led to knowledge sharing, enhanced the educational knowledge and teaching behavior of the doctors, and caused improvements in the clinical learning climate. Entering the training into the early phases allowed the adopters to pick-up the innovations early and more easily.	**What and why it worked as a barrier:** The absence of training, the provision of training to some adopters in a department, or the provision of training in the later phases of the implementation process. The absence of training or the provision of the training in the later phases slowed down the process. Providing training to a subset of the adopters in a department caused a suboptimal learning climate.

*Specific feature of PGME innovation within the Greenhalgh framework, as described in the discussion section of this paper.

continuation on page 90

Table 3 *continuation (3)*
Main attributes found to be important for PGME innovation

	Facilitator to implementation	Barrier to implementation
Attributes of the implementation process		
Interpersonal influence	**What and why it worked as a facilitator:** Facilitate knowledge sharing between program directors, effectively use social networks to spread the innovations and use residents as change agents. Knowledge sharing between program directors led to mutual understanding of the process and led to the exchange of best-practices. The effective use of residents as change agents enhanced their motivation and efforts of knowledge diffusion to their fellow residents.	**What and why it worked as a barrier:** The absence of or suboptimal knowledge sharing and use of residents as change agents. Suboptimal knowledge sharing between program directors slowed down the process because opportunities to exchange best-practices were missed. Not using residents as change agents by their program directors caused these residents to feel left-out, it reduced their motivation and it reduced their efforts to diffuse knowledge of the innovation to their fellow residents, or in a worse case scenario, it caused them to diffuse negative opinions of the innovations to their fellow residents.
Attributes of the organization		
Leadership and management	**What and why it worked as a facilitator:** The presence of good leaders and management at all levels of the projects. The implementation process was accelerated by the presence of good leaders (project leaders, program directors), these were perceived as role models, they inspired, they were ambitious, they experienced high intrinsic motivation, they were entrepreneurs, and they got things done.	**What and why it worked as a barrier:** The absence of good leaders, the lack of "substitute" leaders and the lack of investment in new leaders at all levels of the projects. The implementation process was slowed down by the absence of good leaders (project leaders, program directors): relatively few initiatives and creative action were undertaken and supervisors and residents lacked good role models to inspire them.
Slack resources and support management	**What and why it worked as a facilitator:** The support of management (on all management levels) in providing slack resources, especially educational support. Program directors, supervisors and residents highly appreciated the positive reinforcement by management, such as the Board of Directors. The implementation process was significantly accelerated if the management was willing and able to provide resources, especially educational support.	**What and why it worked as a barrier:** The absence of support of management (on all management levels) in providing slack resources, especially educational support. The implementation process was significantly slowed down if management was unwilling or unable to provide resources. The adopters were less likely to invest into the process without the positive reinforcement of management.
Effective data capture and feedback systems	**What and why it worked as a facilitator:** The application of questionnaires by the national project team to monitor the implementation process. These proved useful for providing feedback on the implementation process and provided a new push for the process.	**What and why it worked as a barrier:** the questionnaires provided only quantitative data (mostly 5-point scale). The lack of qualitative data made it hard to interpret the information acquired.

*Specific feature of PGME innovation within the Greenhalgh framework, as described in the discussion section of this paper.

continuation on page 92

Table 3 *continuation (4)*

Main attributes found to be important for PGME innovation

	Facilitator to implementation	Barrier to implementation
Attributes of the organization		
Tension for change and balance between supporters and opponents	**What and why it worked as a facilitator:** High value attached to medical education in general, and high tension for urgency and need to implement the innovations more specifically, as perceived by preferably all adopters in a department. Adopters were more likely to implement the innovations if they attached high value to medical education. "True believers" in the new learning philosophy experienced high intrinsic motivation and functioned as role models for their fellow supervisors and residents. Residents experienced higher motivation and had more fun when program directors and supervisors also felt responsible and took initiative to execute the instruments.	**What and why it worked as a barrier:** Low value attached to medical education in general, and low tension for urgency and need to implement the innovations more specifically, as perceived by all or some adopters in a department. If some or many supervisors and residents in the department considered education less important than research or medical care, adopters were less motivated to implement the innovation. The extent to which implementation was rewarded, supported and expected within the organizations was found to be a driver of adoption of the particular innovation.
*Difference between general and university hospitals**	**What and why it worked as a facilitator:** Small departments from general hospitals with cohesive communication and decision-making structures on the one hand and effective regional collaboration structures between general and university hospitals on the other hand. Communication and decision-making processes in the smaller departments were more efficient, and members felt more responsible for implementing the innovations than did their counterparts in the larger university hospital departments. University hospitals were perceived as being more in the lead in terms of the regular regional educational collaboration between program directors, the regional allocation of resident training positions, and educational expertise. The implementation process was accelerated by effective regional collaboration structures between program directors that consolidated the strengths of both types of hospitals.	**What and why it worked as a barrier:** Large departments from university hospitals with fragmented communication and decision-making structures on the one hand and the absence of or ineffective regional collaboration structures between general and university hospitals on the other hand. Communication and decision-making processes in the bigger departments were less efficient. The implementation process was slowed down by the absence of or ineffective regional collaboration structures between program directors of general and university hospitals. Knowledge sharing and best-practices exchange opportunities were missed, which slowed down the process.
*Balance training and patient care**	**What and why it worked as a facilitator:** Departments that found a good balance between the personal learning objectives of the resident and the work load of patient care. Preferably, with the renewed curriculum, every resident should have received a tailor-made training according to the required learning objectives. This ambition was limited by the high workload of patient care and the size of the resident group. Furthermore, working under high pressure also provided learning opportunities. A good balance had a facilitating effect on the implementation process.	**What and why it worked as a barrier:** Departments that had a misbalance between the personal learning objectives of the resident and the work load of patient care. In most cases, the misbalance is hanging toward doing patient care. Residents missed valuable learning opportunities and were not accomplishing their personal learning objectives. This slowed down the implementation process.

*Specific feature of PGME innovation within the Greenhalgh framework, as described in the discussion section of this paper.

For supervisors, the most striking behavioral change was that they shifted from providing implicit or no feedback to providing explicit, safe, structured, and repeated feedback on the skills and abilities of residents by using a new feedback technique (Pendleton's rules[21]).
RE:... that, at the end of a shift, supervisors were more likely to say, "Okay, that went well, and be sure to think about this next time" ... in the past, no news was good news.

Although the interviewed adopters expressed a very positive general attitude towards the new structured feedback process, they also identified some difficulties related to giving and receiving feedback, including fear of damaging the relationship, fear of negative feedback and the poor quality of their supervisors' educational skills.
PD: ... people who are evaluated by others never like to be called down, regardless of how nicely you might pack it in a Pendleton formula of "What went well and what could be better?"

The most striking change in the residents' behavior was the development of a pro-active attitude aimed at shaping their own training, instead of passively following it.
RE: ... you're also more conscious about thinking ... what would I like to do here in the next four months, and what would I like to retain? I think this makes you more aware of your learning objectives.

It was also acknowledged, however, that the complexity of work schedules and the structure of the local educational program limited the opportunities for residents to shape their own training.
RE: ...this is your schedule, and then you just do what you have to do, whether you're good at it or not; it doesn't matter because, well, we can't schedule somebody else anyway.

The clear advantages that the respondents attached to the behavioral changes (explicit safe, structured and repeated feedback by the supervisors and pro-active attitude of the residents) had a facilitating effect on the implementation process.

The introduction of structured and scheduled assessment instruments (e.g., the Mini-CEX[22], see Table 1) was perceived as important. Most respondents mentioned that the use of these instruments had produced an improved, standardized, and more objective assessment of clinical skills that allowed more explicit, focused, and balanced reflection on the clinical behavior of residents in specific situations.

SV: ... because you're really observing what's going on there, right? ... you observe the whole situation, from the quality of eye contact to how calm someone is; you also look at things that aren't purely medical ...

Adopters who were more skeptical expressed concern that the accomplishment of a certain number of Mini-CEX assessments had become a goal in itself, although it should be a means to an end. These respondents also noted that considerable time and effort were involved in organizing a Mini-CEX.
RE: ... and then you write an objective for one Mini-CEX per month, even though ... it's obviously not all about a Mini-CEX every month; that defeats the purpose ...

The introduction of the use of the portfolio generated a variety of comments. Proponents pointed out the enhanced opportunity to reflect on their own development and to construct their own training.
RE: ... it really does make you more conscious of "Alright, what can't I do" or "What would I like to learn more about?" ... and you see that you have the opportunity to do certain things during your internship.

Respondents who were more skeptical pointed out the subjective nature of the portfolio and the limitations to learners' ability to shape their own education.
RE: ... you expect inexperienced residents to formulate objectives in areas in which they are not yet comfortable, and I think that's asking too much.

The changes to the structure of the local educational program were considered an important innovation.
RE: And now that we're working with this model, the program directors have also become more clear about the necessity of continuity in the internships in order to realize this plan.

In summary respondents mentioned several advantages and disadvantages to the assessments instruments and the changes to the structure of the local educational program, as discussed above. Due to the lack of either a clear advantage or disadvantage the effect to the implementation process was neutral.

Simplicity and compatibility
The most easily adopted business innovations are those that have a clear advantage, those that are compatible with the values, norms,

and perceived needs of the adopters, and those that are perceived as simple[23]. Many respondents felt that the implementation could have been more successful if some innovations had been simpler and more tailored to existing work processes. The high complexity of the innovations, as perceived by the adopters, had an impeding effect on the implementation process.

RE: … it shouldn't be so grandiose and complex; it ought to be able to fit into the existing structure in some way …

Attributes of the implementation process

External developments

The implementation process was influenced by a number of external developments. The government introduced a national medical training fund and announced that the allocation of funds would be increasingly dependent upon the quality of the PGME provided. This generated skepticism among the program directors, as it remained unclear how this quality was supposed to be measured. On the one hand, this had a negative impact on the implementation process, because program directors, supervisors, and residents associated this process with the allocation of governmental funds. On the other hand, the increased attention to educational quality allowed the national project team to start pilot projects introducing an educational quality care system into PGME. Another external development was the reduction in the number of pediatrics training positions during the project. This decreased motivation and increased the workloads of supervisors and residents, thus allowing less time for the implementation of the innovation. Despite the fact that these factors were very important, the overall effect for the implementation process was neutral.

PD: … many changes at the same time for the same occupational group … well, you can pay attention to only one thing at a time. The discussion about the quality indicators was also really unpleasant, because there was still the feeling that "it was not about quality" …

Appropriate change model. Every situation of change requires a balance between "letting it emerge" and "making it happen." Approaches oriented toward letting the change emerge (diffusion) are essentially passive, and the key mechanisms are contagion and imitation[13]. In contrast, dissemination ("making it happen") is a planned and active process intended to increase the rate and level of adoption above what might have been achieved by diffusion alone. The interviews showed that the national project team was struggling to find the best way to strike this balance. In retrospect, the supervisors and residents thought the national project team should have adopted an approach that tended more toward "making it happen", than "letting it emerge", therefore the chosen strategy had a slightly impeding effect on the implementation process.

PD: …another thing that I noticed in the beginning is that we – and I said this to the national project team – that we were turned loose. We were not told in clear terms what was actually expected of us.

The national project team, however, felt unable to adopt a "make-it-happen" approach, as the team had no formal (i.e., hierarchical) authority to do so.

NPT: We have absolutely no power to apply rules and sanctions. We noticed that it was much more effective to stimulate the entrepreneurship of the program directors…

Good project management

An implementation project can benefit from effective project management, including the tasks of setting explicit goals, defining a clear time frame, and monitoring results[13]. Although the goals that were set initially remained intact during the project, they were modified and extended by the introduction of quality criteria for PGME.

NPT: Then it occurred to us, "How can we make forces that are outside of our control work for us, rather than allowing them to work against us?" This was already included in the project plan, but it wasn't worked out until then … How can we guarantee quality, quality checks?

The interviewees felt that the implementation process was not structured with objectives to be reached at certain points in time. Instead, they perceived it more as an organic process, incorporating relevant developments. Although the loose project management might have had this advantage, overall, the implementation process could have benefited from a tighter project management.

PD: I actually thought that the implementation of the In VIVO project would have a clear beginning and end, but that turned out not to be the case. It does have a beginning, but the process is far from complete.

National and regional implementation strategies and activities

Regional activities (such as organizing regional meetings on a regular basis with all program directors, supervisors and residents to discuss the renewed curriculum, implementation facilitators, barriers and best-practices) were valued more than national ones, however, both had a facilitating effect on the implementation process. The regional meetings generated knowledge sharing and a mutual understanding of the process:

PD Region A: All of the cluster partners were invited, it was well organized, and we could receive concrete information about things that we could change.

RE Region A:... the fact that we got together as a group and conducted the evaluation department by department, what's good and what could be better. I think that was one of the strongest things that took place.

PD Region B: Well, we were – the regional implementation, we didn't ... really stay involved, so we were intensively involved with the implementation in our own hospital.

Educational support

The ability of the regional implementation teams to execute regional and local activities was dependent on support by educational specialists. More successful innovation processes receive ongoing and adequate support in the form of resources[24].

PD: He was indispensible for the entire project ... He knows a lot, he is an excellent instructor, and he knows how to keep things on the right track. Yes, I think that he played a crucial role ...

According to the national project team, implementation could have been more successful if the program directors had received proper organizational support. The implementation process was significantly accelerated wherever such support was arranged.

NPT: Those program directors were not accustomed to the tasks which they were given ... And then, of course, we also had a lot of setbacks because the program directors were trying to do everything as well as they could, but were actually not very good at that type of management.

Human resource factors. Well-organized training in educational methods and the use of the assessment instruments proved useful in accelerating the implementation process. Training generated a more positive attitude toward the innovations, and it led to knowledge sharing, enhanced the educational knowledge and teaching behavior of the doctors, and caused improvements in the clinical learning climate[25].

RE: ... holding the Teach-the-Teacher course for all faculty and the residents in the early phases of the program ... that makes the learning environment much safer and more conscious.

Interpersonal influence in all layers of the project

The national and regional implementation activities were effective mechanisms for communication, interpersonal influence, knowledge sharing and learning, and social networking. This is consistent with previously published work on the importance of communication and interpersonal influence in innovation processes[23], including processes in the context of undergraduate medical education[26], and post-graduate medical education[11].

PD: ... make sure that your counterparts tell you how they are faring with the implementation. Don't do it alone ... try to hear what others have to say, and whether they are referring to the national or the regional meetings. Then you don't have to think up as much on your own, and you don't have to try out everything first hand.

Our results illustrate the importance of the change-agent function fulfilled by the residents. The effective use of these change agents enhanced the diffusion of knowledge to their fellow residents and acted as facilitator to the implementation process. This provides support for research on the effectiveness of peer opinion leaders, who exert influence through their representativeness and credibility[27].

PD Region A: ... one thing that I really appreciated was that it was truly carried out together with the residents. I think that if program directors had just thought this up without them, it would not have been as good, and it would not have been as easy to implement.

PD Region B: I think that the residents were not as motivated as they could have been, because we ignored them to some extent. ... And that would have been quite different if we had started two years ago ...

RE Region B: ... the program directors expected more input from the residents, and then I thought, "Yeah, right. You'll be happy if we just take the minutes."

Attributes of the organization

Leadership and management

Our results support the importance of leadership and management[24] to innovation in health care and undergraduate medical education[26]. Among other positive attributes, good leaders are role models, they inspire, they are ambitious, they experience high intrinsic motivation, they are entrepreneurs, and they get things done. The implementation process was accelerated wherever such support was present.

PD: In my opinion, you have to set an example in this respect; you have to do it yourself, you have to show that it's fun, that it's good, so that the residents will think it's fine. So you do have to create an atmosphere of enthusiasm.

Instead of searching for a program director who possesses all of these qualities, these qualities should be present in the team of supervisors.
PD: Don't be the only one who wants it, because then it won't work. Let everyone evaluate the residents; let everyone conduct feedback meetings…

Slack resources and the support of management
The support of management (on all management levels), especially in terms of providing educational input (a slack resource), was helpful for accelerating the implementation process (in agreement with e.g.[24]).
PD: … the educational support is possible because our Board of Directors considers education important … otherwise, we wouldn't have had that educational capacity.

Effective data capture and feedback systems
Good teams reflect upon their actions[16,24]. The application of questionnaires by the national project team to monitor the implementation process proved useful for providing feedback and had a facilitating effect on the implementation process.
NPT: So all of those moments when something happens again – when you make something visible – they provide a new push.

Tension for change and balance between supporters and opponents
Every supervisor and resident in the team should ideally feel the urgency and need to implement the innovations[24]. The need for change has been found to be an important factor in the success of curricular changes in medical schools[26]. Every team needs at least some adopters who are "true believers" in the new learning philosophy and who experience high intrinsic motivation, as studies have shown that such "true believers" are more likely to adopt the innovation[28].
PD: I really liked that, because I stand behind the objectives of the project: the implementation of modernization – which I consider useful. I think that the doctors and society will ultimately benefit from it – from doctors who finish their education more quickly.

One barrier to change was the feeling that many colleagues in the department considered education less important than research or specialized medical care. The extent to which implementation of the new curriculum and use of the innovations was rewarded, supported and expected within the organizations was found to be a driver of adoption of the particular innovation[29].
PD: As long as science and health care are the most important pillars … that is how we are evaluated; your CV doesn't say much about education; there aren't any prizes for that … so that's always a struggle.

Residents experienced higher motivation and had more fun when program directors and supervisors also felt responsible and took initiative to execute the instruments. This is consistent with recent work on portfolio mentoring[30].
RE: .. in the past, I've had a program director who would say, "Oh, yeah. Portfolio. I haven't read it." … that doesn't motivate people to complete them, if it's not going to be read anyway … Then it just feels like you're doing it for nothing.

Difference between general and university hospitals
Because of the smaller size of their faculty, general teaching hospitals appeared to be at an advantage in the implementation of PGME modernization: communication and decision-making processes were more efficient, and members felt more responsible for implementing the innovations than did their counterparts in the larger university hospital departments.
RE: one advantage of the general hospital is that you've got a smaller group of people and … that people feel responsible for actually doing it. And that provides motivation to do it …

Conversely, university hospitals were perceived as being more in the lead in terms of the regular regional educational collaboration between program directors, the regional allocation of resident training positions, and educational expertise (e.g. educationalists). The leading role played by large, specialized organizations in assimilating innovation has been described previously[13]. Therefore this attribute was a barrier and facilitator, according to the loco-regional organization.
PD: The university hospital obviously takes the lead quite often in a number of matters. This sometimes gives those in the general hospitals the impression that they are straggling behind.

PD: One thing that we always project … is that our region should be strong in its postgraduate educational programs. Because we organize our postgraduate educational programs regionally – this doesn't apply only to us, it applies to all of the specialties as well – our region needs to be so good that, in a few years when the residents can choose, they will say, "I'd like to go to that region, because everything is really well organized there." In this respect, it's thus more in our own interest to cooperate than it is to compete.

Balance between education and patient care

Preferably, in competency-based education, every resident receives a tailor-made training according to the required learning objectives. However, this ambition is limited by the organization of patient care, high workload and the size of the resident group. Therefore, good teams strive to achieve a balance between personal learning objectives of the resident and patient care. The departmental culture defined the result of the balance.

RE: You're obviously always going to be left with the fact that a large group of residents who have to complete the program in six years, and you've just got to see lots of patients.

However, working under high pressure also provided learning opportunities.

PD: A part of your program involves learning how to function under conditions of stress, how to take responsibility in such situations, because you'll have to do that later in practice.

Discussion

This qualitative study described the implementation process of the competency-based Postgraduate Medical Education (PGME) curricula for O&G and Pediatrics. We observed three interrelated groups of factors that functioned as facilitators or barriers to the process: attributes of the innovations and adopters, attributes of the implementation process, and attributes of the organization (see Table 3). The factors influencing the implementation process identified in our study were comparable to factors that have been described previously in the Greenhalgh framework of complex service innovation in health care[13]. We prefer to concentrate our discussion section on four groups of specific features of innovation in the context of PGME which were not documented before. These features fit within the factors of the Greenhalgh framework, therefore they are not in general to be perceived as new, rather, their importance concerns the specific description of their application in the context of innovation in PGME. Our results showed the context to be the dominant factor in complex innovations like implementing a new PGME curriculum. In this specific innovation, the local/regional context determined the speed, the quality and the direction of the implementation process, the extent to which the innovations were implemented and how a factor affected the process. All factors identified in our study were to some extent promoting or impeding to the implementation process dependent on the specific circumstances and context (see Table 3).

The challenge of implementing the CanMEDS roles

The CanMEDS roles (see Table 1) proved difficult to operationalize (or to translate), to implement and to assess – especially the non-medical competencies – in workplace-based training. This can be explained by looking at the attributes of the innovation, of the implementation process and of the organization.

First, the innovation that had to be implemented was under construction, in fact it was a semi finished product. A national curriculum was written but a blueprint how to apply the CanMEDS roles in work-based training was lacking. Users attached some advantages to this innovation (e.g. the potential benefits for the improvement of health care and society), but most users perceived the application in work-based training as very difficult, especially the non-medical competencies (e.g. they were perceived as artificial). This caused users to refrain from the implementation of the CanMEDS roles and to concentrate on the most easily adoptable innovation with the highest perceived benefits, these are the behavioral changes by the supervisor (structured feedback) and the behavioral changes by the resident (pro-active attitude). In general, these behavioral changes were considered as having significant advantages and may therefore be perceived as a positive behavioral change from an educational perspective.

Second, the implementation process lacked clear project management to monitor the troublesome implementation of the CanMEDS roles, and moreover the national project team was unable to attach more to a "making it happen" approach. The national project team succeeded in stimulating the regional implementation teams and program directors into entrepreneurship ("letting it happen"), however this was not enough to counter the implementation problems. Also the teachers (program directors, supervisors) were not trained in educating the CanMEDS roles; the training they were being provided with was mainly oriented towards providing more structured and safe feedback.

Third, from the perspective of the organization, a real sense of urgency to implement the innovations was lacking by the target audience: the program directors, supervisors and residents. They felt the innovations were important, but in general, short term issues (e.g. managing day-to-day health care operations and doing research) were considered more important. It proved difficult for adopters to look beyond the short term issues into the long term goals of the new curriculum, these are the delivery of high quality and transparent health care provided by competent health care professionals.

Regional implementation strategies and educational support

Our results showed (see Table 3) that residents, supervisors, and program directors strongly appreciated any educational (and organizational) support provided, and they attached high value to regional implementation activities. The provision of both educational support and regional implementation activities at the regional and local levels, along with the customization of these activities to the specific needs of the adopters and the situation (current or change) can enhance the success of the implementation process. It has been shown that such targeted support accelerates and facilitates processes of implementation[23]. However, in a PGME curriculum reform in Denmark, educational support had in some aspects an impeding impact on the process[11]. As in the Netherlands, in Denmark the professionals required and requested additional educational support for implementing the renewed PGME curricula. According to the authors, this incongruence may be subscribed to different roles and capabilities of some of the educational advisors in Denmark.

Balance between training and patient care

Although PGME is intertwined with the delivery of health care (residents learn while working), medical education has always been regarded as less important than health care delivery and research. Our results showed (see Table 3) that successful implementation required medical professionals to balance the importance of a given innovation against the constraints that it will impose on their other tasks. To do this organizational changes were needed. Measures some program directors took were: scheduling residents in such a way that they can accomplish their own learning objectives, increasing the duration of clinical rotations to allow for longitudinal observation and steeper learning curves and scheduling regular feedback encounters between program director and residents.

Need for regional inter-organizational networks of hospitals

Our results showed (see Table 3) the importance of collaboration between university and general hospitals in implementing and providing PGME at various levels: between program directors within the same specialty, in providing regional educational support, and with respect to managerial collaboration. The implementation process benefited from strong networks of collaboration at all of these levels. Integrative inter-organizational networks with good governance structures and explicit shared values and goals can help disperse innovations among member organizations[13].

Strengths, limitations, and suggestions for further research

The main strength of our study is that it is amongst the first to provide an in-depth empirical assessment and description of the implementation process of competency-based PGME. The theory-driven selection of respondents of various backgrounds from within the various layers of the project allowed a context-rich assessment and description of the complex implementation process. Although these rich descriptions are highly valued, they are currently lacking in the literature on innovation[13]. Our findings thus confirm and extend existing research into complex innovation processes in the context of health care, undergraduate and postgraduate medical education[11,13,26,31]. The main limitation of our study involves the relatively small number of interviews. For theoretical reasons, we selected two regions, each with two departments. Practical and financial constraints limited the number of interviews to 25.
We cannot rule out the possibility that our results may have been different if we had sampled more regions, more departments, and more respondents, including those with other backgrounds (e.g., members of the Board of Directors or governmental policymakers). Nevertheless, the fact that our findings are largely in agreement with previously described principles of health care innovation suggests that these differences would have been minor. As with most qualitative research, however, caution is required when generalizing the findings to other countries, sectors, and types of innovations and innovation processes.

Table 4

Recommendations to tailor interventions in the context of PGME innovation

	Level*
The challenge of implementing the CanMEDS roles:	
• Translate the national curriculum to a regional and local curriculum that specifies the CanMEDS roles, procedures for work-based learning, and assessment in the context of patient care	N,R,L
• Design the curriculum with the needs of the primary users (program directors, supervisors and residents) in mind to make it more attractive for them to adopt the innovation	N,R,L
• Align the benefits of the renewed curricula directly with the outcomes of health care processes, such as patient safety and team collaboration and communication	N,R,L
Regional implementation strategies and educational support	
• Create coordination of the implementation process (by specialty)	N,R,L
• Establish goals, establish a timeframe, and monitor the results in concordance with the professional	N,R,L
• Balance "letting it emerge" and "making it happen," depending on implementation progression	N,R,L
• Use training as an implementation tool (to raise awareness among users and to learn the required skills and knowledge)	R,L
• Facilitate knowledge sharing through meetings and social networks	N,R,L
• Use residents as change agents	R,L
• Identify and reward good leaders and good teams; ensure continuity	N,R,L
• Organize logistic organizational and educational support	N,R,L
Need for regional inter-organizational networks of hospitals	
• Build strong regional collaboration networks between university and general hospitals	R,L
Balance between training and patient care	
• Achieve a careful balance between education (work-based learning) and patient care	L

*Level at which it is important to apply the practice points: N = national, R = regional, L = local

Conclusion and recommendations

This study has shown that PGME innovation is characterized by a highly dynamic and non-linear complex implementation process, which is influenced by many factors. We showed which factors were important in this context of implementation and why these were important. Although the factors influencing the innovation of PGME are largely similar to those influencing other innovations in health care and undergraduate and postgraduate medical education[11,13,26,32] we identified four specific features of PGME innovation: the challenge of implementing the CanMEDS roles; the importance of regional implementation strategies and educational support; the balance between training and patient care; and the need for regional inter-organizational networks of hospitals. Based on our experience, a number of recommendations can be generated for health care professionals and policymakers to tailor their interventions in the context of implementing PGME curricula (see Table 4).

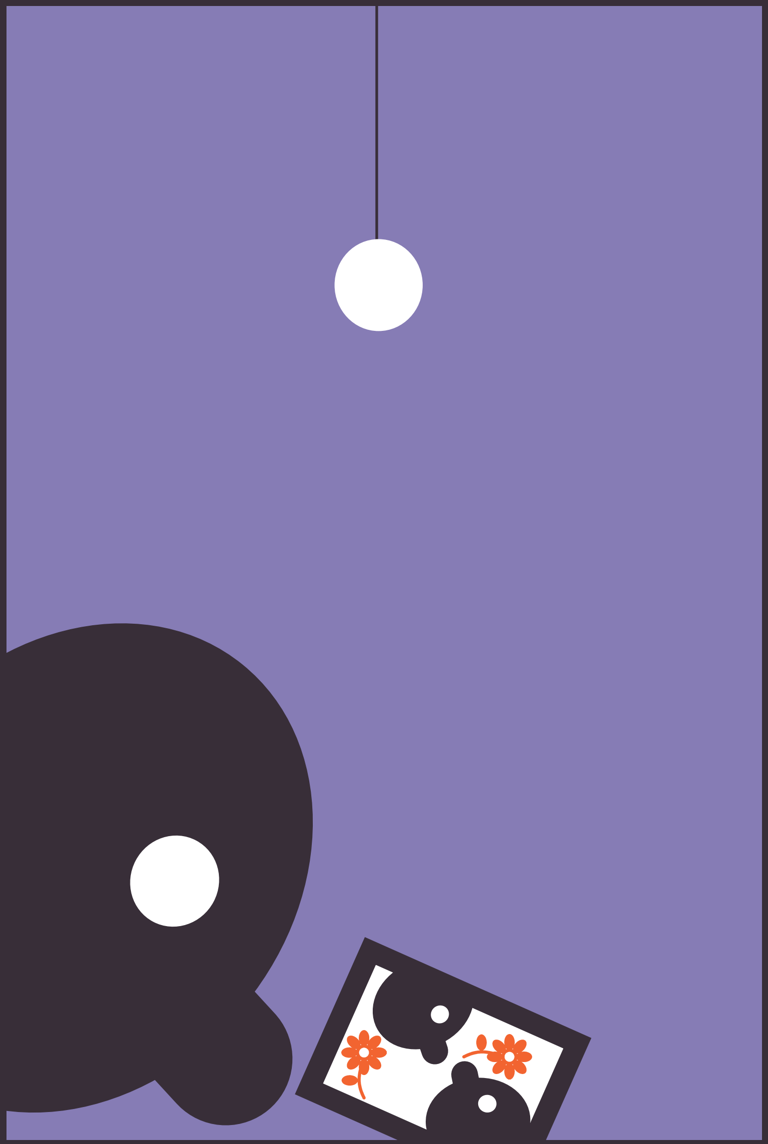
Our results ask for a re-assessment of the implementation of the CanMEDS roles. Additional efforts are required in developing blueprints in how to apply the CanMEDS roles in work-based training in order to achieve the high ambition of training medical professionals who are competent in all roles. Users need to perceive the short term and long term advantages of the innovation and a real sense of urgency in implementing it. One way to achieve this would be to align the benefits of the renewed curricula directly with the outcomes of health care processes, such as patient safety and team collaboration and communication. The innovation as it was implemented was too much designed from an educational and curriculum development viewpoint. The innovation needs to be redesigned with the needs of the primary users (program directors, supervisors and residents) in mind to make it more attractive for them to adopt the innovation.

In addition, we propose coordination of the implementation process at the national, regional, and local levels. This coordination should involve a careful balance between approaches that "let it emerge" and those that "make it happen," dependent upon the phase of implementation. At a minimum, coordination at each level should set goals, establish a timeframe, monitor the results, and facilitate knowledge sharing through meetings and social networks. Our results suggest that such coordination requires the possibility of using formal power to enforce the process (e.g., through the accreditation of training facilities). Support for program directors is probably best organized at the regional and local levels. Identifying and rewarding good leaders and good teams, using residents effectively as change agents, balancing training and patient care appropriately, providing proper local educational and logistic organizational support, and organizing strong regional collaboration networks between university and general hospitals can all accelerate the implementation process.

Practice points

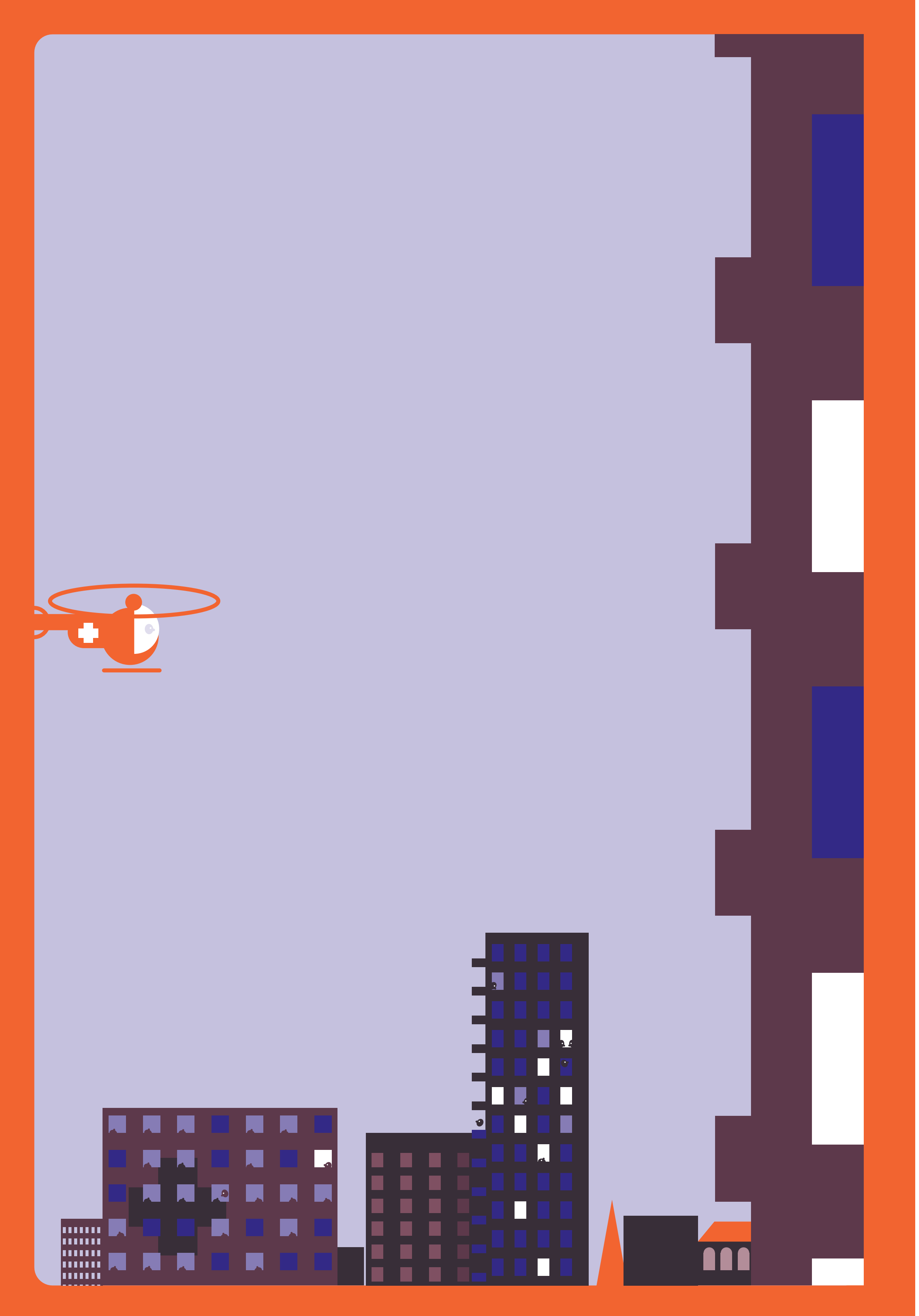
- Despite the increasing attention to competency-based postgraduate medical education (PGME) curricula, research on the implementation process of these curricula is lacking
- The implementation process of competency-based PGME is highly dynamic, non-linear and influenced by many factors.
- The local/regional context determines the speed, the quality, the direction of the implementation process and how specific factors affect this process
- The implementation process is largely dependent on the quality of the initial design of the curriculum, we recommend designing the curriculum with the needs of the primary users (program directors, supervisors and residents) in mind and align the benefits directly with the outcomes of health care processes, such as patient safety, to make it more attractive for the users to adopt the innovation(s)
- For implementing competency-based PGME it is crucial to translate the national curriculum to a regional and local curriculum that specifies the CanMEDS roles, procedures for work-based learning, and assessment in the context of patient care
- For organizing the implementation process it is important to create coordination, establish goals, establish a time-frame and monitor the results. This coordination needs to balance "letting it emerge" and "making it happen". Organizational/educational support and using residents as change agents are both very helpful in accelerating the implementation process

Acknowledgements
The authors wish to thank the program directors, medical specialists and residents of O&G and Pediatrics for their cooperation in this research. This study was funded by the National Board of Health Care Professions and Educations in the Netherlands.



References

1. Frank J, Mungroo R, Ahmad Y, Wang M, De Rossi S, Horsley T. Toward a definition of competency-based education in medicine: A systematic review of published definitions. *Med Teach.* 2010;32:631-7.
2. Frank J, Snell L, Cate O, Holmboe E, Carraccio C, Swing S, et al. Competency-based medical education: Theory to practice. *Med Teach.* 2010;32:638-45.
3. Swing S. The ACGME outcome project: Retrospective and prospective. *Med Teach.* 2007;29:648-54.
4. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach.* 2007;29:642-7.
5. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach.* 2008;30:248-53.
6. Ringsted C, Østergaard D, vd Vleuten CP. Implementation of a formal intraining assessment programme in anaesthesiology and preliminary results of acceptability. *Acta Anaes Scand.* 2003;47:1196-203.
7. Ringsted C, Hansen T, Davis D, Scherpbier A. Are some of the challenging aspects of the CanMEDS roles valid outside Canada? *Med Educ.* 2006;40:807-15.
8. Ten Cate O, Scheele F. Competency-based postgraduate training: Can we bridge the gap between theory and clinical practice? *Acad Med.* 2007;82:542-7.
9. Lurie S, Mooney C, Lyness J. Measurement of the general competencies of the accreditation council for graduate medical education: A systematic review. *Acad Med.* 2009;84:301-9.
10. Wasnick J, Chang L, Russell C, Gadsden J. Do residency applicants know what the ACGME core competencies are? One program's experience. *Acad Med.* 2010;85:791-3.
11. Lillevang G, Bugge L, Beck H, Joost-Rethans J, Ringsted C. Evaluation of a national process of reforming curricula in postgraduate medical education. *Med Teach.* 2009;31:260-6.
12. Jippes E, Brand PLP, van Engelen JML, Oudkerk M. Competency-based (CanMEDS) residency training programme in radiology: Systematic design procedure, curriculum and success factors. *Eur Radiol.* 2010;20:967-77.
13. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
14. Greenhalgh T, Stramer K, Bratan T, Byrne E, Mohammad Y, Russell J. Introduction of shared electronic records: Multi-site case study using diffusion of innovation theory. *Br Med J.* 2008;337:1040-4.
15. Greenhalgh T, Stramer K, Bratan T, Byrne E, Russell J, Potts H. Adoption and non-adoption of a shared electronic summary record in england: A mixed-method case study. *Br Med J.* 2010;340:1399-.
16. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implement Sci.* 2009;4:50.
17. Kennedy TJT, Lingard LA. Making sense of grounded theory in medical education. *Med Educ.* 2006;40:101-8.
18. Ten Cate O. Why the ethics of medical education research differs from that of medical research. *Med Educ.* 2009;43:608-10.
19. Eva K. Research ethics requirements for medical education. *Med Educ.* 2009;43:194-5.
20. Hsieh H, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res.* 2005;15:1277-88.
21. Pendleton D, Schofield D, Tate P, Havelock P. The new consultation: *Developing doctor-patient communication*. Oxford: Oxford University Press; 2003.
22. Norcini J, Blank L, Duffy FD, Fortna G. The mini-CEX: A method for assessing clinical skills. *Ann Intern Med.* 2003;138:476-81.
23. Rogers EM. *Diffusion of innovations.* New York: Free Press; 2003.
24. Gustafson DH, Sainfort F, Eichler M, Adams L, Bisognano M, Steudel H. Developing and testing a model to predict outcomes of organizational change. *Health Serv Res.* 2003;38:751-76.
25. Rubak S, Mortensen L, Ringsted C, Malling B. A controlled study of the short- and long-term effects of a train the trainers course. *Med Educ.* 2008;42:693-702.
26. Bland C, Starnaman S, Wersal L, Moorhead-Rosenberg L, Zonia S, Henry R. Curricular change in medical schools: How to succeed. *Acad Med.* 2000;75:575-94.
27. Fitzgerald l, Ferlie E, Wood M, Hawkins C. Interlocking interactions, the diffusion of innovations in health care. *Hum Relat.* 2002;55:1429-49.
28. Gladwin J, Dixon RA, Wilson TD. Rejection of an innovation: Health information management training materials in east africa. *Health Policy Plan.* 2002;17:354-61.
29. Gershon RR, Stone PW, Bakken S, Larson E. Measurement of organizational culture and climate in healthcare. *J Nurs Adm.* 2004;34:33-40.
30. Dekker H, Driessen E, ter Braak E, Scheele F, Slaets J, van DM, et al. Mentoring portfolio use in undergraduate and postgraduate medical education. *Med Teach.* 2009;31:903-9.
31. Fleuren M, Wiefferink K, Paulussen T. Determinants of innovation within health care organizations. *Int J Qual Health Care.* 2004;16:107-23.
32. Wartman S, Davis A, Wilson M, Kahn N, Sherwood R, Nowalk A. Curricular change: Recommendations from a national perspective. *Acad Med.* 2001;76:S140-5.



Chapter 4

Diffusing (let it happen) or disseminating (make it happen) innovations in health care?

Erik Jippes
Marjolein C. Achterkamp
Jan Pols
Paul L.P. Brand
Jo M.L. van Engelen

Submitted

Abstract

Management has different options for spreading new products. Our study is the first to empirically assess the integral effects of both diffusion and dissemination on innovation adoption. Data on diffusion (as measured by social network density) and dissemination (as measured by formulating objectives and executing focused activities) was gathered using a questionnaire given to 356 medical specialists, nested in 38 teams. We found effects for diffusion and dissemination separately and integrally. This shows the potential for both engaging the social network structures (diffusion) and adding process measures (dissemination) in order to optimize the innovation spreading process.

Keywords: Dissemination of innovation, Diffusion of innovation, Social networks, Density, Medical education.

Introduction

Innovation is a prime enabler for the growth of businesses and for staying competitive[1]. Developing new products is necessary to acquire and keep customers. There is agreement in the literature that effectively structuring the product* innovation process is crucial for (commercial) success[2,3].

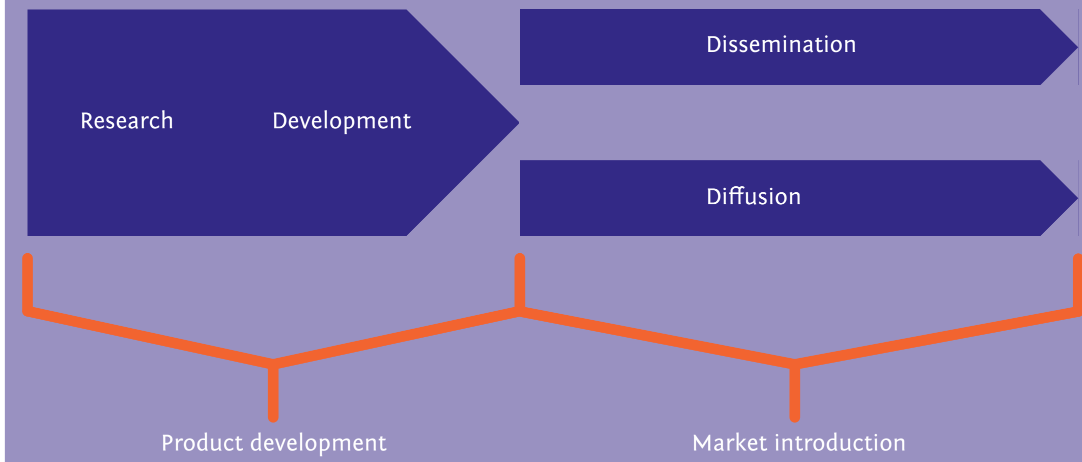
After development, the product needs to be launched and brought to the market[4]. Management can choose between diffusion and dissemination in order to engineer the market introduction and the spreading process of their new products. Diffusion is the process by which an innovation is communicated through certain channels among the members of a social system[5]. Diffusion is an essentially passive process, the key mechanisms of which are contagion and imitation (“let it happen”)[6]. Diffusion is primarily dependent on the structure of the social network. This structure is always present and can be more or less conducive to the diffusion process. On the other hand, management can try to disseminate the innovation. Dissemination is a planned and active process intended to increase the rate and level of adoption above that which might have been achieved by diffusion alone (“make it happen”). Dissemination can be defined as actively spreading a message to defined target groups[6] (see Figure 1 for the product innovation process). Dissemination consists primarily of process measures taken by management to increase the rate and level of adoption. We will follow the definition of adoption by Rogers (2003): “the decision to make full use of the innovation as the best course of action available.”

The question then arises as to which spreading strategy (i.e., only diffusion or additional dissemination measures) is more effective for the rate and level of innovation adoption. The answer is crucial for both the success of the innovation process and for the sparse resources available to spend on the process. Although many studies have evaluated the effectiveness of diffusion or dissemination separately, none have compared the integral effects of both in terms of the rate and level of adoption of a particular innovation. This paper examined the spreading and adoption of an educational product innovation in teams of medical specialists in the Netherlands. The product was developed nationally and had to be adopted by some 200

* A product is defined as anything that can be offered to the market that might satisfy a want or need (products, services, or ideas) (Kotler et al., 2006)

Figure 1

Product innovation process (adapted from Rogers (2003) and Greenhalgh (2004))



medical specialist teams. Management of these teams could either rely on the process of diffusion, or add additional dissemination (process) measures to enhance adoption. We examined the effects (on adoption) of diffusion (measured in our study as management relying on the social network structure contagion effects) and a dissemination approach (management taking process measures to increase adoption).

Theory and hypotheses development

Diffusion of innovations

We used social network analysis tools as the primary measurement of diffusion, based on theoretical, context-based, and methodological reasons.

First, social networks are assumed to play an important role in spontaneous diffusion in general. Social networks influence diffusion by: (1) functioning as channels for communication, social construction, and negotiation of the innovation; (2) increasing the observability of the innovation; and, therefore, (3) reducing the perceived risk by eliminating novelty or uncertainty for potential adopters of the innovation[5,6]. Homophily and contagion are central concepts in spontaneous diffusion through social networks. Homophily is defined by Rogers (2003) as “the extent to which two or more individuals who interact are similar in certain attributes, education, social status and the like”. Homophily plays a large role in relationship building[7]. Between people who are more homophilous, contagion effects occur: An individual adapts his behavior, attitude, and beliefs to those of others, which enhances the diffusion of innovations[5].

Second, we expect social networks to be particularly important in the diffusion of our innovation studied. Our study focused on adoption of the educational innovation “structured competency-based feedback” by medical specialists in teams of medical specialists that train residents. Medical specialists, such as pediatricians or surgeons, have followed an undergraduate medical training to become a medical doctor and have subsequently followed a postgraduate medical specialist training to achieve the license to practice medicine as a medical specialist. A resident is a medical doctor in training to become a medical specialist.

In 2004, the Royal Dutch Medical Association (KNMG-CCMS), a national board responsible for legislation on postgraduate medical specialist training in the Netherlands, introduced competency-based education in postgraduate training throughout the Netherlands[8]. One key innovation introduced by the Royal Dutch Medical Association to support assessment in competency-based education was structured competency-based feedback. Before 2004, feedback in postgraduate medical specialist training programs, if offered at all, was given in an unstructured and sometimes derogatory manner. The use of this innovation by medical specialists was mandated by the Royal Dutch Medical Association, and considerable effort was invested by this organization in promoting the benefits of this innovation. However, the only formal check whether or not the innovation was properly adopted by the medical specialists was in the case of an accreditation visit. Once every five years, every team of medical specialists that train residents receives an accreditation visit during which conditions for continuing the educational program are being examined by an independent visitation committee. Licenses to continue postgraduate training are dependent on successful completion of such 5-yearly accreditation visits. This accreditation visit is in essence the only formal incentive to adopt the innovation as a team. So for proper adoption, the Royal Dutch Medical Association relies heavily on the peer-to-peer networks effects between medical specialists. Therefore, we expect these network effects to be important in the adoption of the innovation structured competency-based feedback.

Adopters assign clear advantages to this innovation, and this is supported by research evidence. For example, Archer (2010) found that feedback, when delivered in a safe, timely, specific, and well-structured fashion, is a valuable mechanism for supervision and learning[9]. The innovation structured competency-based feedback is neither difficult nor costly to adopt; all the adopter has to do is opening up to the principles and essence of the innovation. Therefore, we expect peer influence between medical specialists to play a major role in convincing their colleagues and in teaching their colleagues how to properly apply the innovation.

The third reason for using social network analysis as the primary measurement of diffusion is the availability of a number of well-developed and validated tools and parameters to describe and analyze social networks. Of these parameters, network density is best suited to capture the structure of the social network (the actors in the network and the ties they have with each other). Density can be defined as the proportion of possible ties to the maximum amount possible that are actually present in the network[10]. For example, consider a medium-sized department of around ten pediatricians. These ten pediatricians can be viewed as a social network in which ideas are being exchanged, day-to-day operations are being discussed etc. For this example, we consider the tie “information exchange” and we assume that this tie is “valued” and “nondirectional”. Valued means that the tie can be placed on a continuum between, for example, never (score 1), weekly (score 2) and daily (score 3). Nondirectional means that we cannot distinguish the tie from from actor *i* to *j* and vice versa. The maximum amount of lines in this case is 270 (10 actors times 9 times 3). If all ten pediatricians have contact with each other on a weekly basis (180 lines), the resulting network density is .67.

Our study concentrates on *adoption* of the educational innovation “structured competency-based feedback” by medical specialists in teams of medical specialists that train residents. We focus on within-network density in these teams, because we expect the ties between medical specialists within the team to be of primary importance for innovation adoption, assuming that all teams receive an equal amount of information regarding the innovations from outside the team (this is legitimate since there exists a solid and efficient information distribution system from the Royal Dutch Medical Association to the teams that train residents). This information is always sent to the program director, the medical specialist responsible for the training of residents in a particular team. The program director then diffuses this information to the other medical specialists within the team. Both conceptual and empirical research on within-network density, especially with regard to innovation adoption by medical specialists, is scarce. Before embarking on the analysis of more complex networks between medical specialists from different teams or different hospitals, we first concentrated on the less complex within-network density. Finally, one of the reasons why so few large social network studies have been conducted in the field of medical specialists is that it is extremely difficult to set up these kinds of studies with these very busy and “closed” professionals. Expanding our study into external network ties was therefore considered not to be feasible.

Many scholars worked on density, but in elaborating our hypotheses, we will concentrate on those studies that explicitly looked at within-network density and innovation adoption, or, in the absence of those, at the reasoning in studies that looked at network density and adjacent innovation outcomes, such as diffusion, generation of ideas, and innovation involvement.

The theoretical arguments of the studies that found positive linear effects between network density and innovation outcomes can be traced to the "closure-perspective" put forward by Coleman (1988). This perspective holds that high density fosters identification with group members, promotes trust, and facilitates exchange and collective action[11]. Dense networks create optimal conditions for the exchange of the complex information necessary for innovation in complex organizations[12] and for innovations that contain ambiguous information[13]. Dense networks are often characterized by organic structures and collaborative communication, enabling members to have less inhibited communication and to coordinate their efforts effectively[14]. Dense networks can prevent opportunism. In dense networks, information diffuses rapidly to other actors, and sanctions for deviant behavior can be easily imposed[15]. Dense networks promote more interaction among their actors, allowing knowledge to be more meaningfully understood and effectively exchanged, combined, and utilized. Networks with high density encourage actors to stick with familiar patterns and isolate members from the outside world[16]. Obstfeld (2005) found in a study on the automotive industry (n = 182 persons) that network density was significantly related to innovation involvement.

The theoretical arguments of the studies that found no significant, negative, or curvilinear effects for network density and innovation outcomes may be traced back to the "structural hole perspective," put forward by Granovetter (1983; 2005) and Burt (1992; 2004), which states that less dense networks seem more suitable for new idea penetration into the network. In contrast to dense (closed) networks, less dense (open) networks possess "structural holes," i.e. people with repeated access to individuals in other networks. These connections are called "weak ties", but in essence it is the bridging aspect of these ties, not their strength, that provide individuals who possess them with early access to other and diverse information as opposed to members from their own primary network, thus providing a competitive advantage in seeing good

ideas and in early access to innovations[17-20]. A structural hole indicates that the individual on either side of the hole has access to different flows of information. Maximizing the structural holes, or minimizing redundancy between members, is beneficial for constructing an efficient, information-rich network[17]. Individuals with few weak ties will be deprived of information from distant parts of the social system, and will be confined to the news and views of members in their own network[21]. The availability and transmission rate of new information will be higher for individuals relying on weak ties rather than strong ties[22].

The structural-hole theorists suggest that maybe there is an optimal level of network density beneficial for the spreading of innovations. Networks with low density present both an opportunity structure for generating new ideas and an action problem[23]. Dense networks, conversely, reduce obstacles for the coordinated action necessary to adopt innovations but pose barriers to new idea generation. Shared context and familiarity are likely to contribute to knowledge mobilization up to a point. Beyond this point, increase in density may have a detrimental effect on adoption of innovations; members end up only transferring redundant information to each other[21]. Ties between individuals are needed to exchange information, but ties that are too tight may keep team members from developing, picking up, and using new innovation models[14]. Burt showed that structural holes led to good ideas, but there was no evidence that those ideas led to implementation efforts, let alone implementation success[17]. Gilsing (2008) states that network density limits the potential for novelty creation but enhances the build-up of absorptive capacity[24]. High density inhibits the existence and utilization of diversity, while, at low levels, density does not support absorption sufficiently. A study on idea management confirmed this and showed that more within-network connections resulted in a higher proportion of high-quality ideas, but the most connected groups performed worse, which indicates a certain optimum of within-network connections[25].

To summarize, dense networks may promote a shared set of norms, may lead to trust, prevent opportunism, and could therefore lead to rapid diffusion of information, especially more complex and ambiguous information. The high visibility of actions between team members leads to less deviant behavior and can therefore result in high adoption. Non-adoption is easily observed by other team members. We believe these arguments apply also to the medical specialists in our study. We expect the within-network ties to be important for peer-to-peer influence because medical specialists are a "closed" profession who are expected to absorb new information and adopt innovations faster and better when it comes from a credible source, such as one of their peers in their own team. However, these closely knitted groups of medical specialists could be a problem when it comes to bringing new information into the team. An innovation has to be adopted by quite a few medical specialists before it has a chance to progress into the new shared set of norms. The innovator, in our case the program director, can at first be seen as the deviator from existing norms. Therefore, we also expect the optimum-level hypothesis to apply in our innovation and sample. A certain amount of density between medical specialists is needed to absorb the new information and to adopt the innovation, but ties that are too tight may keep team members from picking up the new innovation in the first place.

Therefore, we hypothesize that:

Diffusion hypothesis 1: *Within-network density will be positively related to innovation adoption.*

Diffusion hypothesis 2: *Within-network density and innovation adoption will have an inverse U-shaped relationship.*

Dissemination of innovations

Dissemination is a planned and active process intended to increase the rate and level of adoption above that which might have been achieved by diffusion alone[6]. The literature is scarce when it comes to dissemination of product innovations in teams of medical specialists. With the help of related work on dissemination approaches in the field of production, marketing, and change management, we propose that it comes down to the following ingredients in characterizing dissemination of product innovations in teams of medical specialists: developing objectives and measures for the diffusion process and planning and developing actions in order to increase adoption.

The fields of production, marketing and change management follow logically from the product innovation process as depicted in Figure 1. Product innovation requires a change in the production (or service delivery) systems of an organization and a change in the marketing necessary to sell the product. Change management includes the tools and techniques required to realize the changes in production and marketing.

An example of a dissemination approach in production is called business process reengineering (BPR). BPR covers a wide range of production improvement tools. Despite disagreement in the literature on the definition of BPR, different views of measuring BPR[26] and different results having been reported for BPR initiatives[27], there is a deeply embedded belief in this approach that carefully structuring the reengineering process with clear objectives, actions and monitoring will lead to better results.

In the marketing literature, dissemination of innovations is conceptualized as (decisions about) product launch and market entry. As with BPR, the literature seems to be largely composed of normative textbooks for a successful product launch, while sound empirical research on the effectiveness of different launch decisions and contextual effects on launch decisions is lacking[28]. For example, Hultink and co-authors (2000) showed that new product launches for consumer products entailed a different set of launch decisions than did those for business-to-business products. Moreover, their findings on launch decisions and product success differed significantly from the normative textbooks[29]. As was the case with BPR, in marketing there is a consistent belief among scholars and practitioners that structuring the product launch and market entry with objectives, actions and monitoring will lead to higher adoption as well. With regard to the innovation in our study – the adoption of an educational product innovation –- we can illustrate this following the example of tactical launch decisions. This means that according to the marketing theorists, the management of the teams of medical specialists should carefully consider the elements of the marketing mix to increase innovation adoption: product tactics (e.g. what are the benefits to the medical specialist of the innovation?), promotion tactics (e.g. how do we promote the benefits and convince the medical specialist to adopt?), distribution tactics (e.g. how is the innovation best distributed to the whole team?), and pricing tactics (e.g. how much time does it take for an adopter to fully comprehend, learn and apply the innovation?).

Change management has its origins in sociology and social psychology, and can be traced back to the classic Lewin ice-cube model (unfreeze, change, and refreeze)[30]. The change-management literature, composed of case studies and anecdotal evidence, appears to lack empirical evidence on which methods are most effective for managing change. Furthermore, from the available evidence, scholars disagree on which change methodologies to apply[31]. The disagreement focuses on applying a planned change or an emergent change methodology[32]. Burnes (2004) concludes that planned and emergent change methodologies are not competitors, nor are they mutually exclusive, while they can be used in combination. They would seem to be allies, with each methodology appropriate to particular change situations[32].

Compared to BPR and product launch decisions, change management seems to align most closely with the dissemination challenges embedded in the innovation adoption of the competency-based structured-feedback by medical specialists. Setting objectives and planning actions is, as in BPR and marketing, at the heart of change management. For example, the Dooley and O'Sullivan (2001) systems innovation model shows four phases: developing objectives and measures, planning and development of actions, implementing actions, and monitoring results[33].

Based on studies from the production, marketing, and change-management literature, we can draw the following conclusions about the effectiveness of different dissemination approaches. First, all fields seems to lack empirical evidence and are composed of case studies, anecdotal evidence, and normative textbooks. Second, no universal recipe for success exists, dissemination approaches need to be focused on the specific situation of the product, market, and organization.

However, when we consider the literature on dissemination approaches from a higher abstraction level, the following focused process measures in characterizing dissemination of product innovations in teams of medical specialists can be distinguished: *developing objectives and measures for the diffusion process and planning and developing actions in order to increase adoption*.
To examine the effect of dissemination approaches, we hypothesize that:

Dissemination hypothesis 3: A dissemination approach (focused process measures: developing objectives and measures for the diffusion process and planning and developing actions in order to increase adoption) applied by management will result in higher innovation adoption.

Materials and methods

Background

We used data on the innovations introduced into the postgraduate medical specialist training programs in the Netherlands to test our hypotheses. There are 27 postgraduate training programs, in medical (e.g., internal medicine, pediatrics, neurology, dermatology), surgical (e.g., surgery, orthopedic surgery, gynecology, ear-nose-and-throat surgery), supportive (e.g., anesthesiology, emergency medicine) and diagnostic (e.g., radiology, microbiology, nuclear medicine) disciplines in the Netherlands. The training programs take place in a total of around 70 teaching hospitals (both university and general teaching hospitals).

Our study focused on the spreading process and adoption of the educational innovation "structured competency-based feedback" by medical specialists in teams of medical specialists that train residents. We chose this innovation because it was the only one that was shared in the same way between all medical specialties, among all of the individual (product)innovations introduced into the postgraduate medical training programs.

In 2004, the Royal Dutch Medical Association (KNMG-CCMS), a national board responsible for legislation on postgraduate medical specialist training, introduced competency-based education in postgraduate training throughout the Netherlands[8]. In competency-based education, medical specialists are trained according to a set of seven core competencies: medical expert, collaborator, communicator, professional, health advocate, management, and scholar[34]. The progress of the resident regarding each of the competencies is assessed regularly using various methods. Such assessment can be formative (guiding future learning, promoting reflection) or summative (making an overall judgment about competence and qualification for higher levels of responsibility)[35]. One key innovation introduced by the Royal Dutch Medical Association to support assessment was the Mini-Clinical Evaluation eXercise (Mini-CEX), with accompanying structured competency-based feedback. The Mini-CEX is a method for assessing clinical competency in real-life clinical practice. After a short observation of a resident demonstrating clinical skills, a qualified medical specialist offers structured-feedback, using a pre-defined scoring format[36]. Assessment in the feedback conversation is formative.

Historically, postgraduate training in the Netherlands was characterized mainly by "learning on the job," and neither the method nor the frequency of feedback was structured. Evaluation of the progress of residents (medical specialists in training) was, therefore, rather informal. Before 2004, feedback in postgraduate medical specialist training programs, if offered at all, was given in an unstructured and sometimes derogatory manner.

More recently, in a pilot project related to the implementation of new postgraduate medical specialist training programs, both residents and medical specialists expressed the view that the introduction of such structured and constructive feedback was the most important innovation in the renewed curricula[37]. It is likely that some medical specialists already applied the method of offering feedback in a structured and constructive fashion before it was promoted as a useful innovation. Because structured and constructive feedback was viewed as a major change in postgraduate medical training programs by the large majority of residents and medical specialists[37] we believe the proportion of such "natural adopters" of the structured-feedback innovation was very small.

We are convinced that our innovation can be considered a genuine product innovation since whether or not an idea, concept, method, product, or service is considered an innovation is dependent on the newness for the adopting organization[38]. Something can be new and innovative for one organization, whereas other organizations have already adopted it. The structured-feedback technique was new and highly innovative for the medical community in the hospitals. For the medical specialists, this innovation consisted of a considerable shift from existing practice.

All innovations together can be viewed as a process innovation. Process innovations are new elements introduced into an organization's production or service operations in order to produce a product or render a service[39]. Competency-based education is meant to improve the process of education, and ultimately to "deliver" a better trained and more competent medical specialist. Each individual innovation, however, can be viewed of as a product innovation. Product innovations can be defined as new products or services introduced to meet an external user or market need[3]. The competency-based structured-feedback, for example, is a new product or service which the users in postgraduate training (medical specialists and residents) can adopt in order to effectively give feedback.

Sample

Data were gathered between 2007 and 2010 from 38 teams (24 radiology teams, four obstetrics & gynecology (O&G teams, five pediatrics teams, and five anesthesiology teams) in the Netherlands. The total sample included 613 medical specialists (370 radiologists, 50 gynecologists, 46 pediatricians, and 147 anesthesiologists) and 571 residents (344 radiologists, 50 O&G physicians, 36 pediatricians, and 141 anesthesiologists). We wanted a surgical discipline (O&G), a non-surgical discipline (pediatrics), a diagnostic discipline (radiology), and a supporting discipline (anesthesiology). From the sample of 613 medical specialists, 420 responded to the questionnaire (69%). After discarding questionnaires with incomplete answers, 356 were available for analysis (58%). From the total sample of 571 residents, questionnaires from all 357 respondents (63%) were included.

Questionnaire

The medical specialists and residents received a structured and validated questionnaire[40]. For the medical specialists, the questionnaire included questions about the independent diffusion variable (density), the independent dissemination variable (focused process measures), and control variables (gender, age, hours of employment, and length of employment). The questionnaire for the residents included questions on the dependent variable (structured-feedback by medical specialists).

Dependent variable

Adoptive behavior: Structured-feedback

The innovation decision process is the process "through which an individual passes from gaining initial knowledge of an innovation, to forming an attitude towards the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision"[5]. Our dependent variable comprised three essential parts of this adoption process: "forming an attitude towards the innovation" and the behavioral changes embedded in "making a decision to adopt or reject" and "implementation of the new idea".

Our innovation concerns "structured-feedback" which needs to be adopted by medical specialists. Structured-feedback is based on "Pendleton's rules"[41]: (1) the feedback is structured, (2) the medical specialist gives the resident the opportunity to give his/her opinion, (3) the medical specialist provides positive points, (4) the medical specialist provides specific points for improvement, and (5) the medical specialist provides the feedback in a "safe" and constructive way. These rules have been very well described and communicated to the medical specialists. Because there are, and always will be, individual differences in how well someone is able to give feedback, we chose not to measure the ability of providing feedback per se, but to assess how well each supervisor applied these five specific feedback rules instead. A medical specialist's ability to properly apply the rules can be measured, regardless of his/her ability to give feedback.

We chose to ask multiple residents to rate each specialist's ability to give the structured-feedback, in order to reach the most reliable estimate of the degree of adoption by each medical specialist. To capture the behavioral changes of the adoption process, every medical specialist in our sample was rated by at least two residents on each of these points on a five-point Likert scale ranging from "totally disagree" to "totally agree." To capture their attitude towards the innovation adoption process, medical specialists rated the question, "Structured-feedback is an improvement in the quality of postgraduate medical specialist training," on a similar five-point Likert scale. The arithmetic averages for (1) the residents' ratings for each specialist on the five points measuring the Pendleton rules, and (2) the medical specialists' answers to the question measuring attitude, were used as the coefficients for individual innovation adoption of structured-feedback by the medical specialists.

Independent variables

Diffusion variables: Ego density

First, we prepared the social network data. We used a "full roster design". Each medical specialist received a list with all names of their fellow medical specialists in their department, and was asked to rate their communication intensity with each of their fellow medical specialists in their own teams. Communication was specified "as communication in the past six months about the introduction of innovations, new methods or procedures, or new developments related to the work situation". The rating was on a six-point scale, ranging from "never" to "less than once a month", "more than once a month", "weekly", "daily" or "more than once daily" (also used by[42]). UCINET VI[43] was used to analyze the data, producing a directed valued graph and a matrix.

In order to test the hypotheses, the data were transformed into an undirected dichotomous matrix (or symmetrical matrix). We used the maximum symmetrizing method to convert the directed matrix into an undirected one, and to correct for missing network data. With the maximum symmetrizing method, the highest rating of communication intensity between two persons is used, or, in the case of missing network data, the rating from one person. Every resulting network was checked in a report with the program director of each team of medical specialists. Furthermore, we computed a so-called QAP correlation to assess whether or not the answers of two persons (from actor *i* to *j* and vice versa) in a particular network corresponded. To dichotomize the valued matrix (ranging from 1 to 6), we recoded the values one and two into zero (no communication). The values three, four, five, and six were recoded into one (communication between medical specialists).

After preparation of social network data, we computed ego density. We used ego density as the measurement for our diffusion hypotheses because we wanted this measurement to be as close as possible to the interaction patterns between individuals. For this reason, we chose ego density, because this density parameter is measured at the individual level. Ego density is the proportion of all possible ties that are present between alters in the ego-centered network. An ego density is the ratio of the degree of an actor to the maximum number of ties that could occur[10]. We calculated this index for every medical specialist in our sample, and used it to test Hypotheses 1 and 2.

Dissemination variables: Focused process measures

We based this variable on the Dooley and O'Sullivan (2001) systems innovation model. They proposed four phases: developing objectives and measures, planning and developing actions, implementing actions, and monitoring results[33]. In line with Christiansen and Varnes (2009), we asked the medical specialists how they perceived the process measures taken to increase the rate and level of adoption. The process measures actually used in everyday practice can differ significantly from those officially declared and described by organizations. Due to sense-making processes, companies adapt their approach to their own context[44].

Medical specialists rated the following questions on a five-point Likert scale ranging from "totally disagree" to "totally agree":

- Have specific shared objectives in the past six months been formulated in your team for the implementation of the educational innovations?
- Have specific shared activities in the past half year been structurally executed in your team to implement the educational innovations?

We calculated both the arithmetic average and the standard deviation of the responses of the medical specialists in every team in order to test Hypothesis 3 (see statistical analysis for more information about the nested structure of the variables). We used the arithmetic average to assess the hypothesized relationship between a dissemination approach used by management (as measured by the above focused process activities) and innovation adoption. Since we asked all team members the above questions, a dissemination approach could be more or less agreed upon by the team members. The standard deviation measures the dispersion of opinions on the process measures chosen by management. We expected the higher the arithmetic average and the lower the standard deviation to the above questions, the higher the innovation adoption.

Control variables

We controlled for the effect of gender, age, length of employment, and hours of employment. Social networks among men and women differ in complex ways, particularly in relation to life stage[45]. Older people tend to have larger and older networks which are less geographically proximal[46]. Decker and co-authors (2001) found a strong association between length of employment and a more negative score on job satisfaction, a more pronounced effect from budget adjustments on individual job-related stress, poorer individual performance quality, and poorer department morale[47]. An increasing number of health care professionals have part-time appointments. Weick and Martin (2006) found no significant differences between part-time and full-time innovators. They seemed to be similar in terms of age, gender, educational level, and the types of innovations they pursued[48].

Data analysis

First we conducted a reliability and factor analysis to look into the validity of our dependent variable. After an initial correlation to check for bivariate patterns in the data, we constructed a hierarchical linear model, to account for the nested structure (individuals within teams within hospitals). The control variables were entered into the model first, followed by the independent variables. Finally, several interaction effects between the independent variables were entered into the model. The independent variable, ego density, was entered on the individual level (Level 1); all other independent variables were entered into the model at the team level (Level 2).
All control variables were entered on the individual level (Level 1).
To assess Hypothesis 2, the squared value of ego density was entered into the model. We also modeled whether or not our independent variables were equally related to both parts of the dependent variable: the attitude assessment and the behavioral assessment. The variables age, hours of employment, and the dissemination variable were centered in the following way before they were entered into the model: Age (minus 30 years), hours of employment (minus 15 percentage points), and dissemination variable (minus 1 point). These variables were skewed. Centering improves model interpretation.

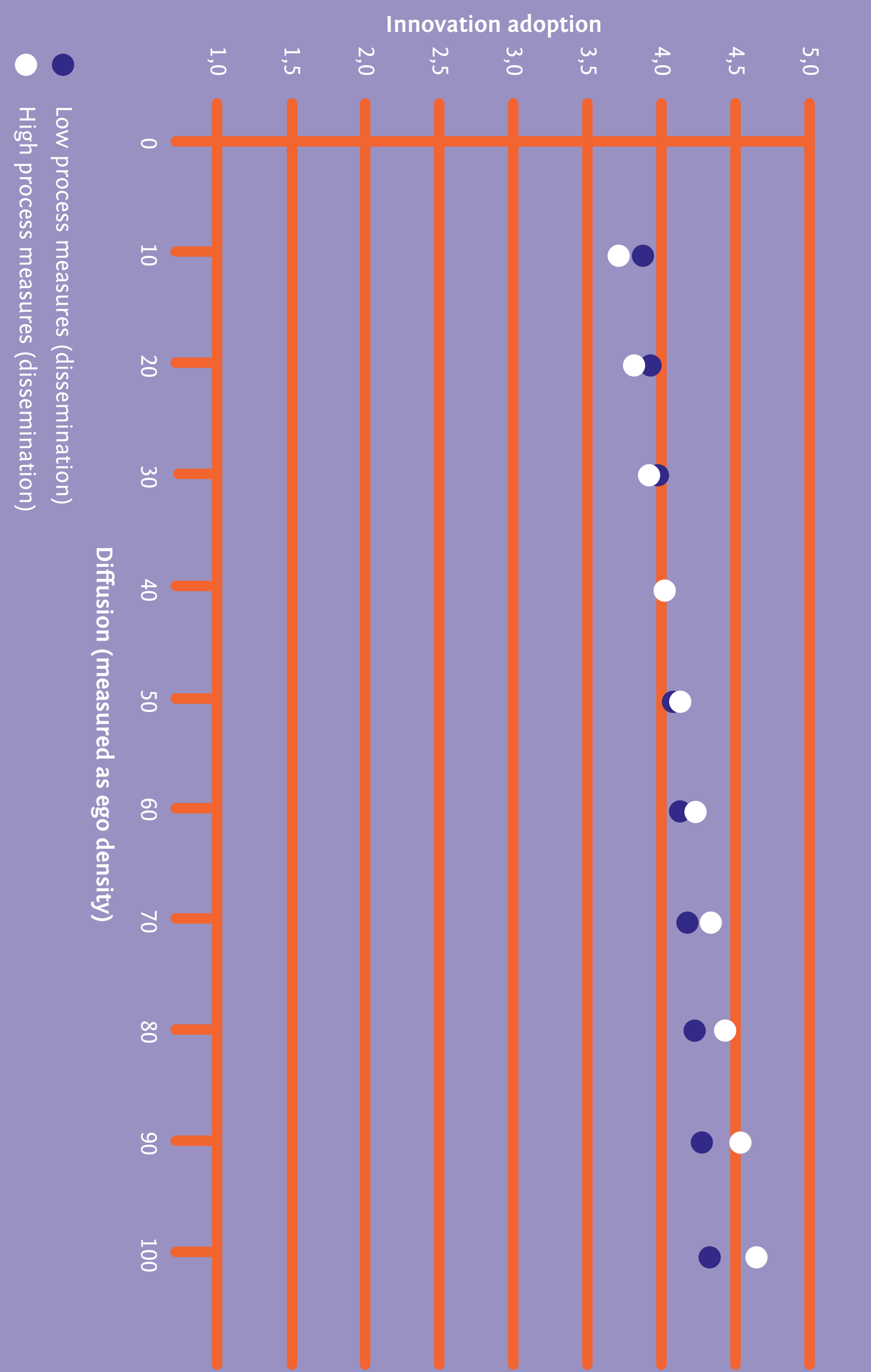
Results

Reliability analysis yielded a Cronbach's alpha of .79 for the six questions that measured the dependent variable "structured-feedback." Factor analysis revealed one construct underneath these questions (eigenvalue of 3.159 and 53% explanation of variance). The assumptions for factor analysis were met. There was no multicollinearity: the Kaiser-Meyer-Olkin measurement was .797 and Barletts' test was significant ($p < .01$). In Table 1 the descriptive statistics and correlation coefficients are presented.

Innovation adoption was weakly, but significantly, positively correlated to density ($r = .09$, $p < .05$) and negatively to age ($r = -.13$, $p < .01$). Density and focused process measures were correlated ($r = .34$, $p < .01$). The control variables showed the following significant correlations: density and hours of employment ($r = .15$, $p < .01$), focused process measures and gender ($r = -.13$, $p < .01$), focused process measures and hours of employment ($r = .22$, $p < .05$), gender and age ($r = -.19$, $p < .01$), gender and hours of employment ($r = -.31$, $p < .01$), gender and length of employment ($r = -.22$, $p < .01$) and age and length of employment ($r = .77$, $p < .01$).

Figure 2

Combined diffusion and dissemination (interaction effect)



Hierarchical linear model

Table 2 shows the results for the regression analysis.

The null model shows that most variance occurs at the individual level. In Model 1, age had a significantly negative relationship ($p < .05$) to innovation adoption. Model 1 explained 5.64% of the variance in innovation adoption at the individual level and 3.03% at the team level. In Model 2 we entered the density variables (diffusion variables) to test Hypotheses 1 and 2. Density showed a significantly positive ($p < .01$), and the squared value of density a significantly negative relationship ($p < .01$) to innovation adoption. Model 2 explained 11.81% of the variance in innovation adoption on the individual level. In Model 3 we entered the dissemination variables to test Hypothesis 3. This slightly improved the model's fit. The model explains 13.23% of the variance on the individual level. The relationship between the dissemination approach (focused process measures) and innovation adoption was of borderline significance ($.05 < p < .10$).

As explained in the methods section, our dependent variable contains an attitude assessment (does the medical specialist have a positive attitude towards the innovation?) and a behavioral assessment (has the medical specialist adopted the innovation?). The model showed that the density variables were significantly related ($p < .01$) to both the attitude assessment and the behavioral assessment. Dissemination was not significantly related to the attitude assessment, but showed a significantly relationship to the behavioral assessment ($p < .05$).

The interaction effect between the diffusion (density) and dissemination (focused process measures) variables was entered in the last step (Model 4). This interaction effect had a significantly positive ($p < .001$) relationship to innovation adoption (see Figure 2). The last model explained 16.10% of the variance at the individual level. Figure 2 shows the moderating effect of dissemination (focused process measures) on the relationship between diffusion (network density) and innovation adoption. With high dissemination, the slope of the relationship diffusion-innovation adoption is steeper. This indicates that adding process measures to the natural rate of diffusion leads to higher innovation adoption.

Table 1
Descriptive statistics and correlations

		N	Scale used	Min.	Max.	Mean	SE	1	2	3	4	5	6
Dependent variable													
1	Innovation adoption	356	1-5	2.25	4.92	4.09	.43						
Independent variables													
2	Diffusion: Ego density	356	0-100	.00	100.00	57.48	35.87	.09*					
3	Dissemination: Focused process measures	38†	1-5	2.30	3.33	2.33	.49	.03	.34**				
Control variables													
4	Gender	356						.01	-.08	-.13**			
	Males	252											
	Females	104											
5	Age	356	Years	30.00	65.00	46.87	8.40	-.13**	-0.5	.02	-.19**		
6	Hours of employment (part-time / full-time)	356	%	15.00	100.00	92.08	14.29	.06	.15**	.22*	-.31**	-.07	
7	Length of employment	356	Years	.00	35.00	10.55	8.40	.09*	.02	.05	-.22**	.77**	.05

† This variable is at the team level (Level 2); this N therefore represents the number of teams

* *p* < .05

** *p* < .01

Table 2

Hierarchical linear model for innovation adoption

	Model 0	Model 1 Control variables	Model 2 Hypotheses 1 & 2	Model 3 Hypothesis 3	Model 4 Interaction effects
Constant	4.130 (.052)	4.105 (.154)	3.981 (.163)	3.587 (.264)	4.111 (.317)
Variables					
Gender (male is reference category)		.014 (.051)	.043 (.051)	.053 (.051)	.066 (.050)
Age		-.007 (.004)*	-.006 (.004)	-.006 (.004)	-.006 (.004)
Hours of employment		.002 (.002)	.001 (.002)	<.000 (.002)	.001 (.002)
Length of employment		.001 (.004)	.001 (.004)	.001 (.004)	.001 (.004)
Diffusion: Ego density			.012 (.002)**	.011 (.002)**	.005 (.003)
Diffusion: Ego density^2			<-.000(<.000)**	<-.000(<.000)**	<-.000(<.000)**
Dissemination: Focused process measures (mean)				.094 (.061)	-.176 (.109)
Dissemination: Focused process measures (standard deviation)				.236 (.133)	.211 (.133)
Interaction Diffusion (ego density) and Dissemination (focused process measures, mean)					.004 (.001)**
Variance					
Level 1 individual	.172 (.013)	.162 (.012)	.152 (.012)	.149 (.011)	.144 (.001)
Level 2 team	.026 (.014)	.025 (.014)	.056 (.025)	.066 (.029)	.081 (.034)
Explained variance					
Level 1 individual		5.64%	11.81%	13.23%	16.10%
Level 2 team		3.03%	0.00%	0.00%	0.00%
-2 Log likelihood	403.809	394.773	365.566	362.068	353.032

* $p < .05$

** $p < .01$

Discussion

This study compared the contributions of diffusion (as measured by the density of the social network) and a dissemination approach (as measured by focused process measures taken by management) to the adoption of an innovation (novel structured-feedback format to evaluate residents in training) by 356 medical specialists in 38 teams. We found support for diffusion and dissemination separately and integrally.

The diffusion variable density had a significantly positive relationship, and the squared value of density a significantly negative relationship to innovation adoption. The dissemination variable (focused process measures) showed no significant relationship to innovation adoption at the $p < .05$ level, but dissemination was significantly related to the behavioral part of our dependent variable. We also found a strong positive relationship for the interaction effect between the diffusion and dissemination variables. Based on the findings, we had to accept Hypothesis 1 (positive effect for network density) and Hypothesis 2 (inverse U-shaped relationship between density and innovation adoption). Hypothesis 3 (positive effect for a dissemination approach) was rejected.

In this study, medical specialists in dense networks showed to be more likely to properly use the new structured-feedback technique. From other research, it is known that the high visibility of actions between team members leads to less deviant behavior and can therefore result in high adoption. Non-adoption is easily observed by other team members[16]. These arguments apparently apply to the medical specialist in our study as well. This could be attributed to the fact that medical specialists are "closed" profession who are expected to absorb new information and adopt innovations faster and better when it comes from a credible source, such as one of their peers in their own team. Our results support the notion of an inverse U-shaped curve for network density. Some (optimum) level of network density is beneficial for innovation adoption. Apparently, too-closely knitted groups of medical specialists could have difficulty when it comes to bringing new information into the team. The innovator, in our case the program director, can at first be seen at the deviator from existing norms. A certain amount of density between medical specialists is needed to absorb the new information and to adopt the innovation, but ties that are too tight may keep team members from picking up new innovations in the first place. This finding is comparable to a study on idea management that showed that more within-network connections resulted in a higher proportion of high-quality ideas, but the most connected groups performed worse, which indicates a certain optimum of within-network connections[25]. Our study showed that also for innovation adoption, a certain optimum of within-network ties is beneficial.

Teams that formulated specific shared objectives for the implementation of the innovations and structurally executed shared activities to implement the innovations experienced showed a trend towards higher innovation adoption ($.05 < p < .10$). Dissemination was not significantly related to the attitude assessment, but showed a significant relationship to the behavioral assessment. Apparently, while dissemination measures have a significant effect on adoption behavior, these measures appear to have no significant effect on forming an attitude towards the innovation. Diffusion (measured as network density) had a significant effect on both. A possible explanation for this finding could be that dissemination in essence is oriented towards behavioral change resulting in adoption. Whether or not an adopter has a positive attitude towards the innovation is of less importance; there is pressure from outside the network to adopt. This is in contrast to the situation of diffusion, where there is no pressure from outside the network, but only from peers through which the process flows naturally. So in order to adopt an innovation, in the case of diffusion someone has to be positive about the perceived benefits, otherwise the person has the choice not to adopt.

Our results indicate that applying an integral approach (diffusion with additional dissemination process measures) is most effective for innovation adoption in health care education. More specifically, the relationship between diffusion (as measured by density) and innovation adoption is steeper (or stronger) under conditions of high dissemination. Adding process measures to the natural rate of diffusion seems to results in higher innovation adoption. This is an interesting finding, since no studies are available that have looked into the integral effects of diffusion and dissemination on innovation adoption. Both bottom up (let it happen) and top down (make it happen) approaches can be used simultaneously and reinforce one another. A plausible explanation could be that paying attention by management to the objectives and executing activities to implement innovations actually reinforces the social network structures, resulting in higher adoption. Another explanation could be that the dissemination measures taken by management focus the content of communication within the social network towards the innovation itself. Medical specialists are naturally focused on their profession, and their communication toward their peers is primarily oriented toward discussing medical issues (such as the diagnosis and treatment of patients). They are not used to discussing innovations, especially ones that are not initiated from or directly related to and beneficial to medical issues (such as competency-based structured-feedback). Possibly, by drawing attention – for example during staff meetings with medical specialists – to innovation issues, the social networks naturally circling around medical issues, can be activated and used in transferring knowledge embedded in innovations. If this is the case, adding dissemination measures towards the natural process of diffusion should be primarily oriented towards learning to discuss innovation-related issues, together with some guidance of the process such as objectives and planned activities. This could be a significant benefit of adding dissemination measures.

However, adding dissemination measures may also impose risks for innovation adoption. Our results show that diffusion (as measured by density) is quite powerful for innovation adoption in itself. Organizational interventions may do more harm than good, especially if they somehow disrupt the natural diffusion process. For example, organizing a staff meeting between medical specialists to discuss the innovation may result in opponents towards the innovation expressing their negative feelings to their peer medical specialist. This negativity could quickly spread to the rest of the team which leaves management with an even bigger challenge in increasing innovation adoption.

Conclusion and managerial implications

Both the natural process of diffusion (as primarily influenced by the structure of the social network) and additional dissemination (process) measures impact innovation adoption. From a managerial point of view, it might be worthwhile to actively influence and compose the structure of the social network, aiming at high (but not too high) density network teams. Some possible structural social network measures that a manager can take are adding or removing team members, introducing job rotation schemes, and altering the frequency of team meetings. Technically speaking, these measures would fall under the heading of dissemination since dissemination includes all measures taken to increase the rate and level of adoption.

To increase the natural diffusion rate and level of adoption (caused by the social network structures), it would be worthwhile for management to add additional dissemination process measures. Some possible process measures are the ones in our study (formulating specific objectives and executing activities), but others are imaginable, for example, inviting experts, organizing peer supervision meetings to share knowledge, and evaluating individual and team performance. For optimal effect, these measures would have to be aligned to the specific change situation (product, market, and organization).

Strengths, limitations, and suggestions for further research

Our study is the first to empirically assess the effects of combined diffusion and dissemination. Moreover, our sample size allowed us to use hierarchical linear modeling; this made it possible to assess individual and team-level variables, and to account for the nested data structure. Our results showed variance on both the individual and team level, thus justifying the use of hierarchical linear modeling.

This study had a number of limitations. First, we focused on innovation spreading within teams of medical specialists, regardless of whether the innovation originated inside or outside a specific team. The spreading process within the teams could have been influenced by social networks that medical specialists might have had outside their own team. These could consist of medical doctors, nursing staff, management, educationalists, management consultants, other support personnel, and professional associations. It would be interesting to examine how these networks are composed and what their effects are in terms of the spreading of health care innovations.

Second, we measured the social network relationships for new developments in departments. To generate more richness in the nature of the social networks, further research might include different kinds of relationships (for example, collaboration, trust, and advice relationships) along with variables which can explain the social relationships found (for example, physical proximities and the personal characteristics of the respondents). A mixture of quantitative and qualitative techniques would be preferable in order to measure these variables.

Third, we chose a cross-sectional research design. A longitudinal approach (combined with simulation methods) might reveal important insights into the dynamics of diffusion and dissemination approaches.

Fourth, our measurement of dissemination was limited to formulating specific objectives and to structurally executing specific activities, both aimed at implementing the innovation. Other operationalizations might be possible, and these might well yield different results. Fifth, our study was limited to innovation in medical training. Although training and health care delivery are interwoven, and the new structured-feedback technique can have a direct impact on health care delivery, clinical errors, and patient safety, we need to be cautious in generalizing the findings from this study to innovation in health care in general. We believe the findings in this study about how educational product innovations in health care are spread have relevance for spreading product innovations in other fields as well. However, since our sample was limited to the health care sector, we need to be cautious in generalizing our findings to other sectors.

Finally, the structured-feedback technique can be defined as an incremental medical educational product innovation introduced into teams of medical specialists. Research indicates that competencies needed for successful radical innovation may differ entirely from those needed for successful incremental innovation[14]. It would be fruitful to examine the effects that diffusion and dissemination have on different types of innovations (simple vs. complex, product vs. process, and imitative vs. radical), and on different types of teams and organizational settings.

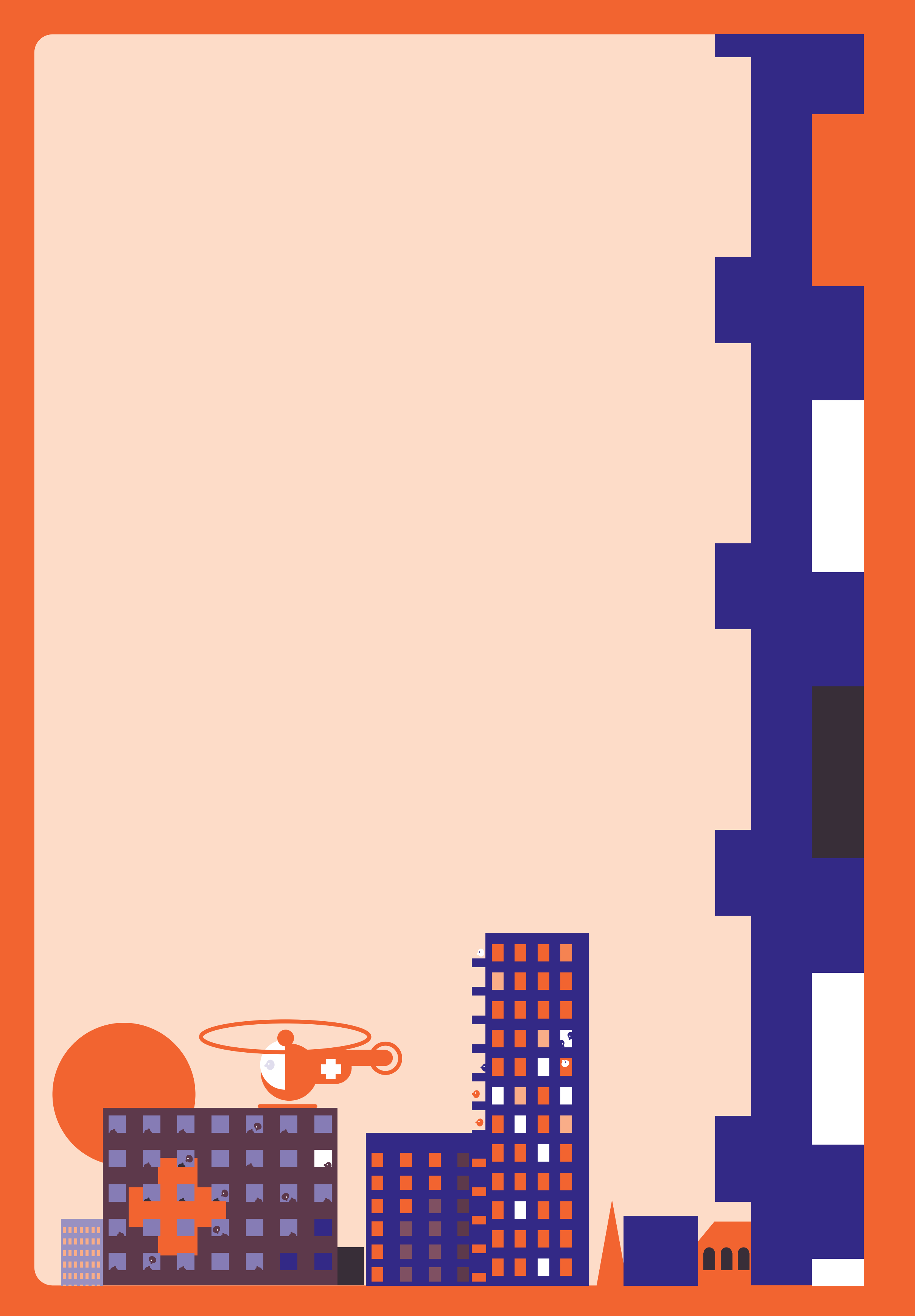
Acknowledgements

We would like to thank the program directors, medical specialists, and residents for their cooperation in this research. We thank Roy Stewart for methodological and statistical advice.

References

1. Kanter R. Innovation: The classic traps. *Harv Bus Rev.* 2006;84:72-83.
2. Ernst H. Success factors of new product development: A review of the empirical literature. *Int J Man Rev.* 2002;4:1.
3. Kotler P, Armstrong G, Brown L, Adam S. *Marketing*. Pearson Education Australia; 2006.
4. Debruyne M, Moenaert R, Griffin A, Hart S, Hultink E, Robben H. The impact of new product launch strategies on competitive reaction in industrial markets. *J Prod Inn Man.* 2002;19:159-70.
5. Rogers EM. *Diffusion of innovations.* New York: Free Press; 2003.
6. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
7. Gibbons D. Interorganizational network structures and diffusion of information through a health system. *Am J Public Health.* 2007;97:1684-92.
8. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach.* 2008;30:248-53.
9. Archer JC. State of the science in health professional education: Effective feedback. *Med Educ.* 2010;44:101-8.
10. Wasserman S, Faust K. *Social network analysis*. Cambridge: Cambridge University Press; 1994.
11. Coleman J. Social capital in the creation of human capital. 1988;94:95-120.
12. Hansen M. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Org Sci.* 2002;13:232-48.
13. Gibbons D. Network structure and innovation ambiguity effects on diffusion in dynamic organizational fields. *Acad Man J.* 2004;47:938-51.
14. Brockman B, Morgan R. The moderating effect of organizational cohesiveness in knowledge use and new product development. *J Acad Mark Sci.* 2006;34:295-307.
15. Ahuja G. Collaboration networks, structural holes, and innovation: A longitudinal study. *Adm Sci Q.* 2000;45:425-55.
16. Padula G. Enhancing the innovation performance of firms by balancing cohesiveness and bridging ties. *Long Range Plann.* 2008;41:395-419.
17. Burt R. Structural holes and good ideas. *Am J Soc.* 2004;110:349-99.
18. Burt R. *Structural holes*. Cambridge, MA: Harvard University Press; 1992.
19. Granovetter M. The strength of weak ties: A network theory revisited. *Soc Theory.* 1983:201.
20. Granovetter M. The impact of social structure on economic outcomes. *J Econ Perspect.* 2005;19:33-50.
21. Fliaster A, Spiess J. Knowledge mobilization through social ties: The cost benefit analysis. *Schm Bus Rev.* 2008;60:99-117.
22. Ruef M. Strong ties, weak ties and islands: Structural and cultural predictors of organizational innovation. *Industrial & Corporate Change.* 2002;11:427-49.
23. Obstfeld D. Social networks, the tertius iungens orientation, and involvement in innovation. *Adm Sci Q.* 2005;50:100-30.

24. Gilsing V, Nooteboom B, Vanhaverbeke W, Duysters G, Oord vd A. Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Res Pol.* 2008;37:1717-31.
25. Björk J, Magnusson M. Where do good innovation ideas come from? exploring the influence of network connectivity on innovation idea quality. *J Prod Inn Man.* 2009;26:662-70.
26. Herzog N, Polajnar A, Tonchia S. Development and validation of business process reengineering (BPR) variables: A survey research in slovenian companies. *Int J Prod Res.* 2007;45:5811-34.
27. Burnes B. Managing change and changing managers from ABC to XYZ. *J Man Dev.* 2003;22:627.
28. Hultink E, Hart S, Robben H, Griffin A. New consumer product launch: Strategies and performance. *J Strat Mark.* 1999;7:153-74.
29. Hultink E, Hart S, Robben H, Griffin A. Launch decisions and new product success: An empirical comparison of consumer and industrial products. *J Prod Inn Man.* 2000;17:5-23.
30. Lewin K. Frontiers in group dynamics: Concept, method and reality in social science; social equilibria and social change. *Hum Relat.* 1947;1:5-41.
31. Drummond-Hay R, Bamford D. A case study into planning and change management within the UK national health service. *Int J Publ Sect Man.* 2009;22:324-37.
32. Burnes B. Emergent change and planned change – competitors or allies? *Int J Oper & Prod Man.* 2004;24:886-902.
33. Dooley L, O'Sullivan D. Structuring innovation: A conceptual model and implementation methodology. *Ent & Inn Man Stud.* 2001;2:177-94.
34. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach.* 2007;29:642-7.
35. Epstein R. Assessment in medical education. *N Engl J Med.* 2007;356:387-96.
36. Norcini J, Blank L, Duffy FD, Fortna G. The mini-CEX: A method for assessing clinical skills. *Ann Intern Med.* 2003;138:476-81.
37. Jippes E, Luijk SJ, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Barriers and facilitators to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study. *Med Teach* in press. 2012.
38. West MA, Anderson NR. Innovation in top management teams. *J Appl Psychol.* 1996;81:680-93.
39. Baregheh A, Rowley J, Sambrook S. Towards a multidisciplinary definition of innovation. *Man Dec.* 2009;47:1323-39.
40. Jippes E, Achterkamp MC, Brand PLP, Kiewiet DJ, Pols J, van Engelen JML. Disseminating educational innovations in health care practice: Training versus social networks. *Soc Sci & Med.* 2010;70:1509-17.
41. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication.* Oxford: Oxford University Press; 2003.
42. Kratzer J. *Communication and performance.* Groningen: ICS; 2001.
43. Borgatti SP, Everett MG, Freeman LC. Ucinet 6 for windows. Needham, MA: *Analytic Technologies*; 2002.
44. Christiansen J, Varnes C. Formal rules in product development: Sensemaking of structured approaches. *J Prod Inn Man.* 2009;26:502-19.
45. Antonucci T. Social relations: An examination of social networks, social support, and sense of control. In: Birren J, Schaie KW, editors. Handbook of the psychology of aging (5th ed.). San Diego, CA, US: Academic Press; 2001. p. 427-53.
46. Ajrouch K, Blandon A, Antonucci T. Social networks among men and women: The effects of age and socioeconomic status. *J Ger Ser B: Psych Sci & Soc Sci.* 2005;60:311-7.
47. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man.* 2001;19:1-12.
48. Weick C, Martin J. Full-time and part-time independent inventors: Rising with the creative class. *Int J Entr & Inn.* 2006;7:5-12.



Chapter 5

Disseminating educational innovations in health care practice: Training versus social networks

Erik Jippes
Marjolein C. Achterkamp
Paul L.P. Brand
Derk Jan Kiewiet
Jan Pols
Jo M.L. van Engelen

Published in *Social Science & Medicine* 2010; 70:1509-1517

Abstract

Improvements and innovation in health-service organization and delivery have become more and more important due to the gap between knowledge and practice, rising costs, medical errors, and the organization of health care systems. Since training and education is widely used to convey and distribute innovative initiatives, we examined the effect that following an intensive Teach-the-Teacher training had on the dissemination of a new structured competency-based feedback technique of assessing clinical competencies among medical specialists in the Netherlands. We compared this with the effect of the structure of the social network of medical specialists, specifically the network tie strength (strong ties versus weak ties).

We measured dissemination of the feedback technique by using a questionnaire filled in by Obstetrics & Gynecology and Pediatrics residents (n = 63). Data on network tie strength was gathered with a structured questionnaire given to medical specialists (n = 81). Social network analysis was used to compose the required network coefficients.

We found a strong effect for network tie strength and no effect for the Teach-the-Teacher training course on the dissemination of the new structured feedback technique. This paper shows the potential that social networks have for disseminating innovations in health service delivery and organization. Further research is needed into the role and structure of social networks on the diffusion of innovations between departments and the various types of innovations involved.

Keywords: The Netherlands, Medical education, Social networks, Strong ties, Weak ties, Diffusion, Dissemination, Innovation, Training, Physicians, Communication.

Introduction

Innovation in health service delivery and organization has become a central issue. The reasons for it becoming so range from failure to use the available scientific knowledge[1], to rapidly rising costs due to changing demographics and medical technology[2], medical errors[3], and the very organization of the health care systems themselves[4]. Many innovation projects often fail to meet expectations. There are six forces which seem to drive or kill innovations: players (friends and foes), funding, policy, technology, customers, and accountability[5].

Many of the innovations in health care organizations are implemented by following a training course or other kind of education. The expenditure incurred for training and education is considerable. In the USA an average health care organization's (500-999 FTE) annual training expenditure exceeds $150,000[6]. The average annual direct training expenditure per FTE in health care in the USA is $862, which constitutes on average 12% of profit[7].

As a result, the question then arises as to how effective training and education actually are in distributing and transferring novel ideas, new health concepts, and technologies. Are there more effective, less time-consuming and therefore cheaper ways to disseminate knowledge in health care practice?

In this paper we will examine the effects of an intensive Teach-the-Teacher training course versus the effect that the structure of the social network has on the adoptive behavior of medical health care professionals. More specifically, we will look at the effect of network tie strength on the dissemination of a new structured feedback technique among medical specialists.

Theory and hypotheses development

Training and education: The effect of Teach-the-Teacher training

A large amount of literature is available on the effectiveness of training and education in general. This has been summarized in a meta-analysis showing a medium to large effect for training and education when using a composite measure of Kirkpatrick's (2006) evaluation criteria (i.e., reaction, learning, behavior, and results)[8]. Another review showed, that training and education lead to important benefits for individuals and teams, organizations and society[9].

Meyers & Sivakumar (1999) identified training and education as key factors influencing organizational innovation and implementation. Training can create a positive climate and attitude by increasing familiarity and technical competence. Training leads to more specialization which, in turn, can lead to a broader knowledge base, stimulate the exchange of ideas and foster innovation. Training can also lead to more professionalism, more boundary-spanning activities and increased openness to new methods and ways[10].

Steinert et al. (2006) conducted a review of the effectiveness of teaching faculty development initiatives in medical education. They defined faculty development as those planned programs which prepare institutions and faculty members for their academic roles, including teaching, research, administration, writing, and career management. Steinert et al. limited their review to faculty members' teaching abilities in medicine. Faculty development activities appeared to be highly valued by the participants, who also reported changes in learning and behavior. However, student/resident evaluations did not always reflect the behavioral changes that the participants perceived, and changes in organizational practice and student learning have not been investigated very frequently since[11]. Recently a long-term controlled study showed that Teach-the-Teacher courses, aimed at improving the didactic skills or teaching abilities of doctors, significantly increased doctors' didactic knowledge and teaching behavior, and led to improvements in the clinical learning climate[12].

Thus, while the beneficial effects of training and education in organizations per se have been well documented, the effects of Teach-the -Teacher training in health care organizations are less clear.

To examine the effect of Teach-the-Teacher training on adoptive behavior, we hypothesize that:

Hypothesis 1: *Teach-the-Teacher training will have a positive effect on the adoptive behavior of medical health care professionals.*

Social networks and the effect of strong and weak ties

Social networks are assumed to play an important role in the diffusion and dissemination of innovations. Social networks influence diffusion by (1) functioning as channels for communication, social construction and negotiation of the innovation, (2) by increasing the observability of the innovation and, therefore, (3) by reducing the perceived risk by eliminating novelty or uncertainty for potential adopters of the outcome of the innovation[13-15]. Social relationships and social networks are critical for the sustainability of health care innovation[16].

Diffusion of innovations through social networks has been studied from a number of perspectives in a variety of fields and disciplines[13,17], for example, in the diffusion of family planning[18] and health campaigns[19]. Despite the importance that interpersonal influence through social networks has on the diffusion of innovations, some sectors and organizations and some types of innovation have been ignored in prior research. In a comprehensive literature review on the diffusion of innovations in health service organizations, Greenhalgh et al. (2004) concluded that, although the conceptual framework of social networks had been extensively applied to the adoption of particular health technologies, the empirical literature on the social networks of health professionals as related to the diffusion of innovations in service delivery and organization (as opposed to health technologies) was extremely sparse.

A social network can be defined as a finite set of actors and the relationships defined between them[20]. In the application of Social Network Analysis (SNA), generally speaking actors can be interpreted as discrete individuals, or groups of individuals, business units, entire organizations or even as countries. The same holds for relationships or relational ties. In the case of SNA, these can be just about everything, for example, an exchange of products, trust, power, friendship or information. In the application of SNA to the diffusion of innovation, the actors are individuals, groups and business units (intra-organizational) or organizations (inter-organizational), and the relational ties consist of the exchange of information, communication, friendship or trust. The configuration of the actors and the relational ties they have with each other – or the structure of the social network itself – can influence the diffusion of innovation in several ways. Two perspectives emerge in the literature: the "strength of strong relational ties" and the "strength of weak relational ties"[21]. The first perspective is mainly based on the notion of homophily. Homophily is defined by Rogers (2003) as "the extent to which two or more individuals who interact are similar in certain attributes, education, social status and the like." Between people who are more homophilous, contagion effects occur: An individual adapts his behavior, attitude and beliefs to those of others, which then enhances the diffusion of innovations. Homophily and communication reinforce each other: The more communication there is between members – or the stronger the tie between the actors – the more likely they are to become homophilous[15]. Strong relational ties also provide more opportunities for instruction and feedback, which can in turn enhance successful adoption[21] Interpersonal contacts and communication increase the observability of the innovation and therefore reduce the perceived risk by eliminating novelty or uncertainty for the potential adopters of the outcome of the innovation[13,15]. More frequent communication decreases potential risk and results in higher diffusion and adoption. Social networks with a larger number of strong ties – or dense networks – create optimal conditions for the exchange of the complex information necessary for innovation in complex organizations[22] and for the origin of high quality ideas[23].

Weak relational ties also have their advantages. External (weak) ties (or structural holes) allow new innovations to be identified and captured from outside the network. Individuals whose networks span structural holes have early access to diverse information, which provides them with a competitive advantage by seeing good ideas and having early access to innovations. Weak ties are often more important in spreading information or resources because they tend to serve as bridges between otherwise disconnected groups and to facilitate access to different contacts and resources[24,25].

West et al. (2005) studied the social networks of clinical directors in medicine and directors in nursing. The former have significantly denser, more cohesive and more horizontal social networks than the latter and both groups tend to discuss important professional matters with others who are similar in terms of profession, gender, age, and seniority, with clinical directors being more extreme in this regard[26]. Coleman et al. (1966) studied the diffusion of a prescription drug Gammanym among 125 physicians in four American Midwestern communities. They found the more links and contacts a physician was involved in, or the stronger the ties a physician had, the more likely he or she was to be an early user of Gammanym. Physicians who were more isolated in the network adopted the drug considerably later. The impact upon the integrated physicians was quick and strong, while the impact upon isolated physicians was slower and weaker, though not absent[27].

A recent study on prescribing behavior of General Practitioners (GPs) in Italy found no significant relationship between the strength of GPs' ties (as measured by degree centrality) and their performance (meeting a drug expenditure target)[28].

No study looked into the combined effect of the strength of strong and weak ties on the adoptive behavior of health care professionals.

For the successful diffusion of innovations, both strong and weak relational ties seem to be necessary. Weak ties are necessary to acquire new ideas and strong ties are necessary for subsequent implementation[24,29].

To examine the effect of strong and weak ties in the medical setting, we hypothesize that:

Hypothesis 2: *Medical health care professionals who have strong ties will be more likely to show adoptive behavior.*

Hypothesis 3: *Medical health care professionals who have weak ties will be more likely to show adoptive behavior.*

Hypothesis 4: *Medical health care professionals who have both strong and weak ties will be more likely to show adoptive behavior than medical health care professionals who only have either strong or weak ties.*

Methods

Background: Innovations in postgraduate medical training in the Netherlands

We used data from the innovations in the postgraduate medical specialist training programs in the Netherlands to test our hypotheses. The Netherlands has 27 postgraduate training programs (for example, surgery and pediatrics) following medical school and they take place in eight university and about 60 non-university teaching hospitals. Postgraduate training has consisted mainly of "learning on the job." Residents (medical specialists in training) work under the supervision of a team of qualified medical specialists and learn by reflection on experiences. In this program, neither the method nor the frequency of feedback is structured. Evaluation of the progress of residents is, therefore, rather informal. Ethical approval was not necessary for this study. In 2004, the Royal Dutch Medical Association (KNMG-CCMS) introduced competency-based education in postgraduate training throughout the Netherlands[30]. Traditionally residents had been trained according to a pre-defined input (for example, number of operations, number of months in clinical consultation and practice). Assessment was limited to checking whether these numbers were met. In competency-based education, medical specialists are now trained according to certain competencies: medical expert, collaborator, communicator, professional, health advocate, management and scholar[31]. The periodic assessment which takes place now focuses (using a variety of methods) on knowledge and skills possession relevant to clinical practice.

Key innovations introduced by the Royal Dutch Medical Association were the use of the Mini Clinical Evaluation eXercise (Mini-CEX) and the use of structured competency-based feedback[32]. The Mini-CEX is a method of assessing competencies in real-life clinical practice. It consists of a short observation of a resident demonstrating clinical skills, and is carried out by a qualified medical specialist using a pre-defined scoring format, followed by a structured feedback conversation[33]. The method and frequency of the structured feedback are outlined. As a result, medical specialists are expected to adopt a novel structured feedback format. The Mini-CEX and structured feedback were to be adopted and implemented by all teams of medical specialists that train residents. Our study focuses on the dissemination process of structured feedback within teams of medical specialists. The innovation could originate either from outside or from within the group.

Sample

The medical specialties of Obstetrics & Gynecology (O&G) and pediatrics were the first in the Netherlands to implement the innovations in their curriculum[34]. Data were gathered in 2007 from four O&G departments and five pediatrics departments in the Netherlands. Two of the authors were members of the implementation team for the O&G and Pediatrics curriculum in the region, which allowed access to the research field. The total sample consisted of 105 gynecologists and pediatricians and 86 residents in O&G and pediatrics.

Data gathering

The medical specialists and residents received both a structured and validated questionnaire (see below). The questionnaire for the medical specialists included questions about the following topics:

- Independent variables: • Whether a Teach-the-Teacher training course was followed • How they evaluated their communicational ties with fellow medical specialists
- Control variables: Gender, age, attitude, hours, and length of employment

The residents were asked to assess how capable the medical specialists were in giving structured feedback (dependent variable).

Dependent variable

Adoptive behavior: Structured feedback

We used the "structured feedback" given by medical specialists to residents as the dependent variable. Structured feedback is based on "Pendleton's rules"[35] and consists of the following components:

- The feedback is structured
- The medical specialist gives the resident the opportunity to give his/her opinion
- The medical specialist provides positive points
- The medical specialist provides specific points for improvement
- The medical specialist provides the feedback in a "safe" way

Every medical specialist was rated by at least two residents on the above components on a five-point Likert scale ranging from "totally disagree" to "totally agree."

Independent variables

Teach-the-Teacher training

Many medical specialists in our sample had followed a Teach-the-Teacher course which was aimed at improving the didactic skills or teaching abilities of the participants. The training consisted of three sequential two-day courses. Registration for the second and third courses was dependent upon successful completion of the first course. The introductory course comprised training in structured feedback, training in the Mini-CEX, and the basics of adult learning. The second course comprised training in daily educational practice, which includes organizing day-to-day training for residents and adapting the training to the learning styles of the residents. The third course included training in periodic interviews for the formative and summative assessment of residents. Participants in the courses were medical specialists from different specialties and hospitals in the Netherlands; among these participants were the gynecologists and pediatricians in our sample. We examined whether participation in one, two and three courses in the five years previous to the questionnaire had had any impact on adoptive behavior (Hypothesis 1).

Social Network Analysis: Preparation of data for the social network independent variables

We used SNA techniques to measure the social network independent variables. Medical specialists rated their communication intensity with their fellow medical specialists in their own departments. The communication was specified "as communication in the past half year about the introduction of innovations, new methods or procedures, or new developments related to the work situation." The rating was on a six-point scale, ranging from "never," to "less than once a month," "once in three weeks," "weekly," "daily," or "more than once daily" (also used by[36]).

The resulting data was analyzed using UCINET VI[37]. The answers given by the respondents resulted in a directed valued graph and a matrix. "Directed" means that the relational tie (in this case, communication) of one person to another is either present or not. "Valued" means that the relational tie can range between "never" and "more than once daily." Graphs and matrices are useful techniques in SNA to represent social networks. In order to test the hypotheses, the data needed to be transformed into an undirected dichotomous matrix (or a symmetric matrix). We used the maximum symmetrizing method to convert the directed matrix into an undirected one and to correct for missing network data. This meant that the highest rating of communication intensity between two persons was used or, in the case of missing network data, the rating from one person. To dichotomize the valued matrix (ranging from 1 to 6), we recoded the scores as follows. The values one and two were recoded into zero, which means there is no communication. The values three, four, five and six were recoded into one, which means there is a communication relationship between medical specialists.

Strength of strong ties: Degree centrality
Persons that have stronger ties to others are more central in the social network[20]. Three centrality measurements can be distinguished: degree, betweenness and closeness. Degree centrality refers to persons who are the most visible in the network; these are persons who have a large degree of direct contact or are adjacent to many other persons and have strong ties with other people. Since this index captures direct or strong ties, we calculated it for every medical specialist and used it to test Hypothesis 2 (see Appendix 1 for the calculation of this index).

Strength of weak ties: Betweenness centrality
Betweenness centrality refers to individuals who are literally on the communication paths between two other actors. These actors are central because they potentially control information between two non-adjacent persons[20]. These persons are not necessarily strongly tied to other people. On the contrary, they have a lot of weak ties with a lot of people and serve as bridges for spreading information and resources between otherwise disconnected groups. This index represents the ratio of the number of times an actor is on the geodesics of other actors to the maximum amount possible. In other words, it represents the relative proportion that an actor is on the shortest path between two persons; therefore this index represents an actor's indirect or weak ties. We used the standardized index to test Hypothesis 3 and calculated this centrality measurement for every medical specialist (see Appendix 1 for the calculation of this index).

Strength of strong and weak ties: Closeness centrality
Closeness centrality refers to persons who can quickly interact with all others; these actors can be very productive in communicating information to the other persons in the network[20]. Persons with high closeness centrality have a great "reach" across the network. Closeness centrality can be viewed as persons who have both strong ties (high direct contacts) and weak ties (a lot of indirect ties). The index is the inverse of the sum of the distances from actor *i* to all other actors. As distances decrease the centrality index increases. This index captures both direct or strong ties and indirect or weak ties, since distances can be short (direct or strong ties) or long (indirect or weak ties). We standardized this index and used it to test Hypothesis 4 (see Appendix 1 for the calculation of this index).

Interviews: Validation of the social network independent variables
All program directors of the different departments in our sample were interviewed to validate the social network and the individual centralities of the medical specialists found. Every social network was visualized for the six communication intensities and the program directors could indicate possible flaws in the network. For two networks, minor adjustments for individual centralities had to be made. Overall, the program directors strongly agreed with the social networks found.

Control variables
Numerous control variables may have an effect on social networks and innovation. The following are included in this study.

Gender
It has been widely recognized that social networks among men and women differ in complex ways, particularly in relation to life stage[38]. Other studies have confirmed there is gender difference in social networks[39].

Age
Age can influence social networks. Older people tend to have larger and older networks which are less geographically proximal[40]. Age difference in network structure may reflect differing roles and possibilities according to life stage.

Attitude
Meyers et al. (1999) hypothesized positive motivation, attitudes and commitment to the innovation as factors in facilitating implementation. They drew upon research done on management information systems, decision support systems, and telemarketing innovations. Attitude and motivation seem to be just as important in innovation adoption and implementation in health care as well[41]. Medical specialists rated the question, "Structured feedback is an improvement of the quality of postgraduate medical specialist education," on a five-point Likert scale ranging from "totally disagree" to "totally agree."

Hours of employment (part-time versus full-time employment)
An increasing number of health care professionals have part-time appointments. The influence of part-time employment on innovation is unclear. Weick & Martin (2006) found no significant

differences between part-time and full-time "inventors." They seemed to be similar in terms of age, gender, educational level, and the types of inventions they pursued[42]. Storey et al. (2002) looked into the effect of flexible employment contracts on product and process innovations. It turned out that flexible working was found to be a consequence rather than a driver of innovation[43].

Length of employment in the organization

Relatively few studies have addressed length of employment in relation to innovation. Decker et al. (2001) found the longer a person worked in an organization, the more negative the scoring on job satisfaction, the effect of budget adjustments on individual job-related stress, the quality of individual performance, and department morale[44]. On the other hand, the resource-based theorist would argue that organizations must build on and maintain the resources and capabilities needed to compete[45]. Based on this it can be argued that length of employment actually has a positive influence on innovation.

Statistical analysis

To test for bivariate patterns in the data, we conducted an independent *t*-test for equality of means. Subsequently, we conducted a blockwise multiple regression analysis to assess multivariate patterns and to correct for partial correlations. Hierarchical linear modeling (multi-level analysis) was not used due to the limited number of departments in our sample (nine). At least ten observations on the highest level are necessary[46], but preferably more[47], in order to analyze the data using a random intercept model. The control variables were entered into the multiple regression model first, followed by the independent variables, according to the way they were presented in the theory and hypotheses development section of this paper. Betweenness centrality was transformed by a logarithmic transformation into a more normally distributed variable. Lastly, three interaction effects were entered into the model; these are the interactions between the Teach-the-Teacher training coefficients and the three centrality indexes. The assumptions of multicolinearity, independent errors and heteroscedascity were checked and the model was corrected for outliers. To achieve enough power and to minimize the possibility of a "type I error," we used a sample size of 81 in the regression analysis. This sample size is sufficient with regard to the expected effect size and the number of predictors in the model[48].

Results

From the total sample of 105 gynecologists and pediatricians, 95 responded to the questionnaire (90%). Ultimately a total of 81 gynecologists and pediatricians were included after deleting questionnaires with incomplete answers and those with outliers. From the total sample of 86 residents, questionnaires from all 63 respondents (73%) were included.
Reliability analysis yielded a Cronbach's alpha of .82 for the five questions that measured the dependent variable "structured feedback." Factor analysis revealed one construct under these questions (eigenvalue of 3.042 and 61% explanation of variance). The assumptions for factor analysis were met. There was no multicolinearity; the Kaiser-Meyer-Olkin measurement was .729 and Barlett's test was significant ($p < .01$). In Table 1 the descriptive statistics are presented.

Independent t-test

From the *t*-test results it follows that only closeness centrality causes significant differences ($p < .01$) in the average adoptive behavior (Table 2 and Figures 1 to 5).

Regression analysis

The assumptions for regression analysis were met[49]. The residuals are independent (Durbin Watson is 1.536), there is no multicolinearity (VIF did not exceed 3.284 and the Pearson correlation did not reveal any correlations above .81), there is no heteroscedascity, and the residuals seem to be normally distributed. Table 3 shows the results for the regression analysis. In the base model, age had a significantly negative relationship ($p < .01$) to adoptive behavior. The base model explains 11% of the variance in adoptive behavior. In Step 1 we entered the Teach-the-Teacher training participation coefficient. This caused no significant improvement in the model. Teach-the-Teacher training, therefore, had no significant relationship to adoptive behavior. In Step 2 we entered degree centrality to test the strong tie hypothesis. This significantly improved the model's fit ($p < .05$) with an additional 6.5%. Degree centrality had a significantly positive relationship ($p < .05$) to adoptive behavior. Betweenness centrality was entered in Step 3 (weak tie hypothesis) without significantly improving the model's fit. In the next step, closeness centrality (strong and weak tie hypothesis) was entered into the model, which led to an additional significant 10.5% improvement ($p < .01$) in the model's fit. Closeness centrality had a significantly positive relationship ($p < .01$) to adoptive behavior. After adding

Table 1

Descriptive statistics for medical specialists

	N	Scale used	Min.	Max.	Mean	SE
Dependent variable						
Adoptive behavior	81	1 – 5	2.81	4.87	3.92	.46
Independent variables						
Teach-the-Teacher training	81	0 – 3				
No course followed	26					
One course followed	55					
Two courses followed	18					
Three courses followed	7					
Degree centrality	81	0 – 100	15.79	100.00	77.41	22.35
Betweenness centrality (transformed)	81	0 – 100	.00	1.13	.30	.33
Closeness centrality	81	0 – 100	45.00	100.00	78.85	19.47
Control variables						
Gender	81					
Males	43					
Females	38					
Age	81	Years	31.00	63.00	47.45	8.02
Attitude	81	1 – 5	2.00	5.00	4.44	.69
Hours of employment (part-time vs. full-time)	81	%	50.00	100.00	91.05	11.85
Length of employment	81	Years	.12	29.00	9.67	7.37

Table 2

Independent *t*-test results for adoptive behavior

Independent variables		N	Mean	SE	*t*	*df*
Teach-the-Teacher training						
	No course followed	26	3.93	.41	.142	79
	One course followed	55	3.92	.48		
	No course followed	26	3.93	.41	.591	42
	Two courses followed	18	4.01	.41		
	No courses followed	26	3.90	.44	.453	32
	Three courses followed	7	3.99	.54		
Degree centrality						
	High (> = mean (77.41))	45	4.00	.43	1.615	79
	Low (< mean (77.41))	36	3.83	.48		
Betweenness centrality						
	High (> = mean (.30))	31	3.87	.48	-.852	79
	Low (< mean (.30))	50	3.96	.45		
Closeness centrality						
	High (> = mean (78.85))	43	4.06	.45	3.124**	79
	Low (< mean (78.85))	38	3.76	.42		

* $p < .05$

** $p < .01$

Figure 1-4

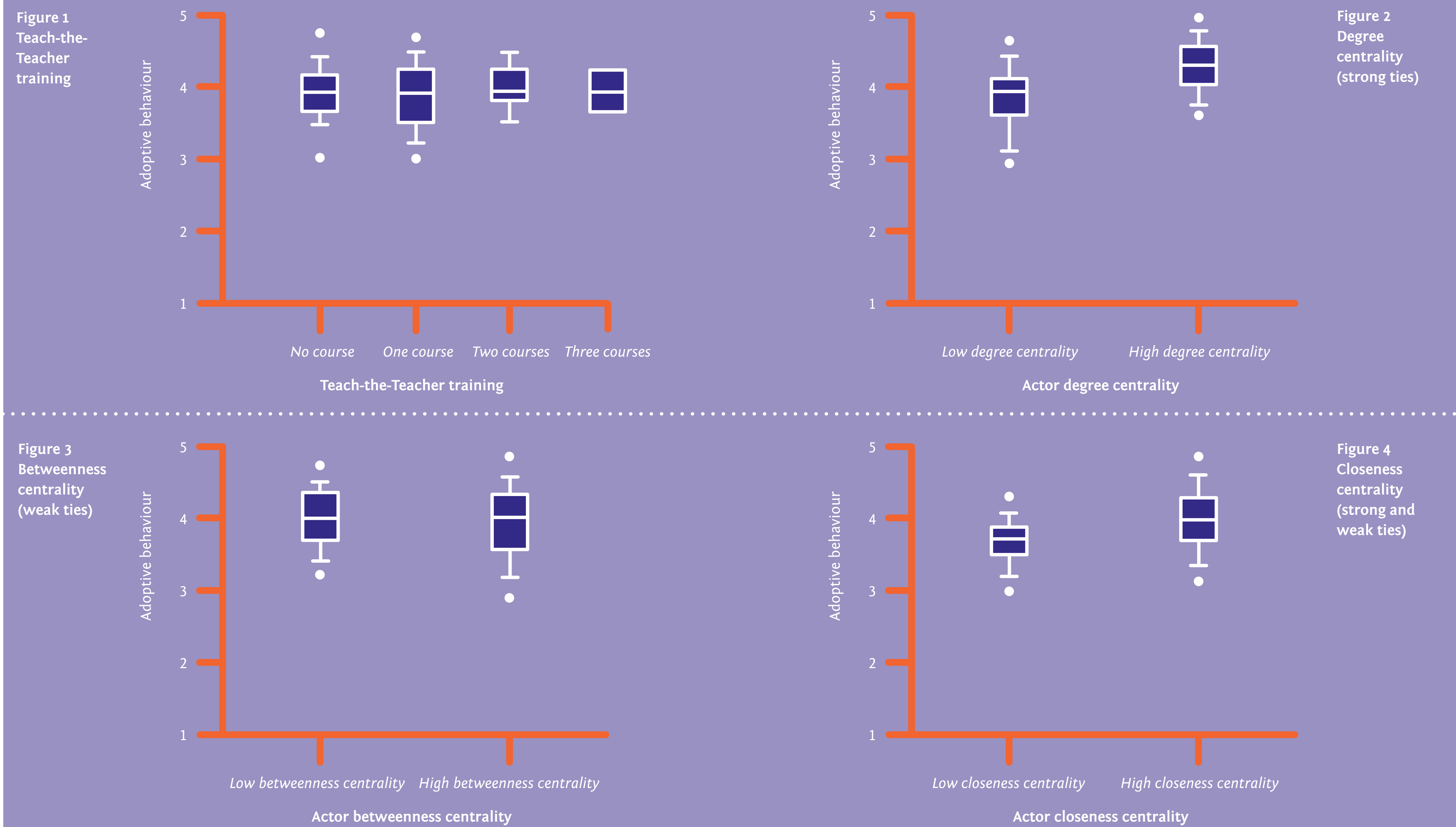
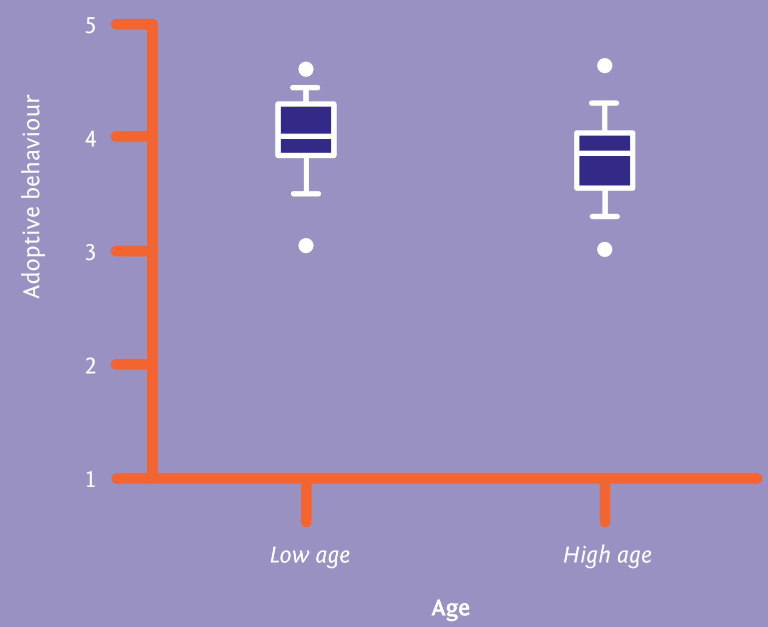


Figure 1
Teach-the-Teacher training
Adoptive behaviour
5
4
3
2
1
No course
One course
Two courses
Three courses
Teach-the-Teacher training
Figure 2
Degree centrality (strong ties)
Adoptive behaviour
Low degree centrality
High degree centrality
Actor degree centrality
Figure 3
Betweenness centrality (weak ties)
Adoptive behaviour
Low betweenness centrality
High betweenness centrality
Actor betweenness centrality
Figure 4
Closeness centrality (strong and weak ties)
Adoptive behaviour
Low closeness centrality
High closeness centrality
Actor closeness centrality

Figure 5



closeness centrality to the model, degree centrality was not significantly related to adoptive behavior anymore. In the last step, the interaction effects were entered into the model. This step caused no significant improvement to the model ($F = 2.288$, $p = .086$). We excluded this step from Table 3, since an interaction term is uninterpretable unless the overall F test reaches significance[50], and because the interaction effects are not included in the hypotheses.

Discussion

This study compared the contributions of Teach-the-Teacher training and social networks to the dissemination of an innovation in health care (adopting a novel structured feedback format to evaluate residents in training). No effect was found from a two to six day Teach-the-Teacher training course. This is in agreement with previous findings from a systematic review that found that student/resident evaluations did not always reflect the behavioral changes in teaching abilities participants perceived after following a faculty development program[11]. Although Teach-the-Teacher training can improve didactic knowledge and skills[12], this by itself is apparently not enough to adopt the innovation successfully.

On the other hand, we found a strong effect for social networks, with a strong association of closeness centrality to adoptive behavior both in the t-test and the regression analysis and a moderate effect of degree centrality for adoptive behavior in the regression analysis. Age was also important. With increasing age, medical specialists seem to be less likely to show adoptive behavior. It could be plausible that residents identify more with younger medical specialists. It is also possible that younger medical specialists are more familiar with structured feedback because their own medical training was already more oriented towards this innovation. Based on the findings, we had to reject Hypothesis 1 (effect of Teach-the-Teacher training) and Hypothesis 3 (weak ties). Hypothesis 2 (strong ties) and Hypothesis 4 (strong and weak ties) were accepted.

Network analysis

In this study, the medical specialists with both strong and weak ties were more likely to properly use the new structured feedback technique. This is in agreement with Burt (2004) who stated that both strong and weak ties were necessary. Weak ties are necessary for capturing innovations from outside the network and providing early access to diverse knowledge and resources, strong ties for

Table 3
Regression analysis for adoptive behavior

N = 81	B	SE	Beta
Base model			
Constant	5.23	.67	
Gender	-.09	.12	-.10
Age	-.03	.01	-.55**
Attitude	.03	.07	.04
Hours of employment	.00	.00	-.03
Length of employment	.02	.01	.35
Step 1: Hypothesis 1			
Constant	5.22	.68	
Gender	-.07	.13	-.08
Age	-.03	.01	-.51**
Attitude	.03	.08	.04
Hours of employment	.00	.00	-.03
Length of employment	.02	.01	.36
Teach-the-Teacher training	.05	.06	.09
Step 2: Hypothesis 2			
Constant	4.51	.71	
Gender	-.03	.13	-.03
Age	-.03	.01	-.51*
Attitude	.00	.07	.00
Hours of employment	.00	.00	.02
Length of employment	.02	.01	.33
Teach-the-Teacher training	.05	.06	.09
Degree centrality	.01	.00	.28*

* $p < .05$
** $p < .01$

continuation on page 172

implementing the innovations. It is also in agreement with Herzlinger (2006) who identified players (friends and foes) as a key driver or killer for innovations in health care. Friends and foes form the social networks which distribute innovations.

We found a significant contribution for degree centrality (strong ties) to the regression model until closeness centrality (strong and weak ties) was added. This is in line with Fattore et al. who found no significant relationship between a GPs degree centrality and performance[28]. The interaction effect between degree centrality and closeness centrality was not found in the bivariate t-test which legitimates the use of the more comprehensive multivariate regression analysis as an additional test. The interaction effect makes sense, since closeness centrality captures both strong and weak ties. One might expect the same interaction effect for betweenness centrality (weak ties). However, since this effect was not found, it can be concluded that strong ties are more important here than weak ties.

There are a couple of explanations for these findings. Actors with more weak ties could experience information overload. Passing information along to others could be time-consuming. These actors are more oriented towards passing information along and have less time to adopt the innovation themselves properly[36]. Since we measured proper adoption of the innovation and not first contact, this explanation could be plausible. Second, medical specialists are a relatively homophilous group; they are similar in educational background, job and social status[26]. Homophily and communication reinforce each other: The more communication there is between members – or the stronger the tie between actors – the more likely they are to become homophilous[15]. So we could expect strong ties to play an important role in the adoption of innovations within the social networks of medical specialists. The third explanation could lie in the fact that the innovation studied – feedback technique – contains relatively complex information. Weak ties are more suitable for conducing relatively simple information and strong ties for diffusing complex information[22]. An important final explanation could be the connection with the Teach-the-Teacher training. Since medical specialists who followed the Teach-the-Teacher training course heard, saw and learned the new structured feedback technique, this innovation had already been introduced into the departments. In other words, there were no weak ties needed anymore to penetrate the departments.

Table 3 *continuation*

Regression analysis for adoptive behavior

N = 81	B	SE	Beta
Step 3: Hypothesis 3			
Constant	4.51	.71	
Gender	-.03	.13	-.03
Age	-.03	.01	-.51*
Attitude	.02	.07	.02
Hours of employment	.00	.00	.03
Length of employment	.02	.01	.33
Teach-the-Teacher training	.03	.06	.06
Degree centrality	.01	.00	.29*
Betweenness centrality (transformed)	-.22	.16	-.16
Step 4: Hypothesis 4			
Constant	4.34	.67	
Gender	-.09	.13	-.10
Age	-.03	.01	-.44*
Attitude	.02	.07	.03
Hours of employment	-.00	.00	-.06
Length of employment	.02	.01	.29
Teach-the-Teacher training	.05	.05	.10
Degree centrality	.00	.00	.01
Betweenness centrality (transformed)	-.30	.15	-.22
Closeness centrality	.01	.00	.43**

R^2 = .102 for base model (p > .01)
ΔR^2 for step 1 = .008 (p > .05)
ΔR^2 for step 2 = .065 (p < .05)
ΔR^2 for step 3 = .021 (p > .05)
ΔR^2 for step 4 = .105 (p < .01)
Total R^2 = .302

* p < .05
** p < .01

We can draw the following conclusions. The most important factors influencing the diffusion of the new structured feedback technique among medical specialists are the strong and weak ties they have within their social networks. These seem to be more important than training and education. From a managerial point of view, it could be worthwhile to actively engage and compose social networks to disseminate innovations among health care professionals. We already know the importance of opinion leaders, gatekeepers, and lead users in innovation processes. In our paper we showed that it was possible to identify these key individuals using Social Network Analysis. After identification of these individuals, they can be harnessed for the dissemination of innovations. They can be incorporated in change initiatives, help to overcome resistance among their colleagues, and follow training and education on new health technologies and innovations.

Limitations and suggestions for further research

This study had a number of limitations. First, we focused on the dissemination of innovations within teams of medical specialists regardless of whether the innovation originated inside or outside a specific team. The dissemination process within the teams could be influenced by social networks that medical specialists might have with other individuals outside their own team. These individuals range from medical doctors, to nursing staff, management, educationalists, and management consultants, as well as other support personnel. It would be interesting to examine how these networks are composed and what the effects are on the dissemination of health care innovations.

Second, the study was carried out at the level of the individual, and not at the departmental level. For example, while we looked at individual degree centralities in departments, all individual degree centralities can also be aggregated into a group degree centralization index. This network level perspective could reveal important insights into the impact that the network structure has on effective diffusion and adoption of innovations in health care. Hospitals are characterized by high specialization, which leads to many informal social networks. Further studies are needed to investigate how these networks interact and how their composition can facilitate effective innovation.

Third, this study had a relatively small sample size (n = 81) composed of two medical specialties. It would be interesting to examine whether the same conclusions could be drawn from a larger sample size that included more medical specialties. The inclusion of more departments would also make it possible to conduct hierarchical linear modeling. This might improve the model by accounting for the nested structure of the data and by adding departmental level independent variables.

Fourth, the negative findings for Teach-the-Teacher training need to be interpreted with some caution. We did not work with an experimental design and we did not measure the effectiveness of the Teach-the-Teacher training with multiple criteria (e.g., Kirkpatrick's criteria of reaction, learning, behavior and results[51]). The primary endpoint here was the degree of adoptive behavior by medical specialists as assessed by their residents. Furthermore, the effectiveness of the Teach-the-Teacher training on the teaching behavior of the study participants was not studied.

Fifth, we measured the social network relationships for new developments in the departments. To generate more richness in the nature of the social networks, further research might include different kinds of relationships (for example, collaboration, trust, and advice relationships) along with variables which can explain the social relationships found (for example, physical proximities and the personal characteristics of the respondents). A mixture of quantitative and qualitative techniques would be preferable in order to measure these variables.

Finally, the study was limited to innovation in medical training. Although training and health care delivery are interwoven and the new structured feedback technique can have a direct impact on health care delivery, clinical errors and patient safety, we need to be cautious in generalizing the findings from this study to innovation in health care as a whole.

The structured feedback technique can be defined as a complex incremental process innovation; complex, because adopters are asked to learn new non-medical knowledge and skills and integrate these into daily practice. Process innovations are new elements introduced into an organization's production or service operations in order to produce a product or render a service[52]. The structured feedback technique improves the learning process of the resident and, therefore, improves the process of health care delivery. The focus of incremental innovations is on the renewal and improvement of existing products or services and technologies[52]. The new structured feedback technique is a renewal of and an improvement on the existing medical specialty training programs. It would be interesting to examine the effects that network tie strength and social network structures have on different types of innovations (simple vs. complex, product vs. process, and imitative vs. radical) in medical education and primary health care processes.

Acknowledgements
We thank the program directors, medical specialists and residents of Obstetrics & Gynecology and pediatrics for their cooperation in this research. We thank Roy Stewart for methodological and statistical advice and support.

Appendix 1

Calculation degree centrality (strong ties)

Degree centrality is calculated as $DC\ (n_{i+}) = x_{i+} = \sum_j x_{ij} = \sum_j x_{=ji}$

where x_{ij} is the direct contact from actor i to actor j[20].

We standardized this index with $\frac{DC\ (n_i)}{g-1}$ where g is the group size, and used to test Hypothesis 2.

Calculation betweenness centrality (weak ties)

Betweenness centrality is calculated as $BC\ (n_i) = \sum_{j<k} g_{jk}\ (n_i)\ /\ g_{jk}$

where $g_{jk}\ (n_i)$ is the number of geodesics (shortest path between two actors) that contain actor i and g_{jk} is the total number of geodesics present in the network[20]. We used the standardized index $\frac{BC\ (n_i)}{(g-1)(g-2)/2}$ (where g is the group size) to test Hypothesis 3 and calculated this centrality measure for every medical specialist.

Calculation closeness centrality (strong and weak ties)

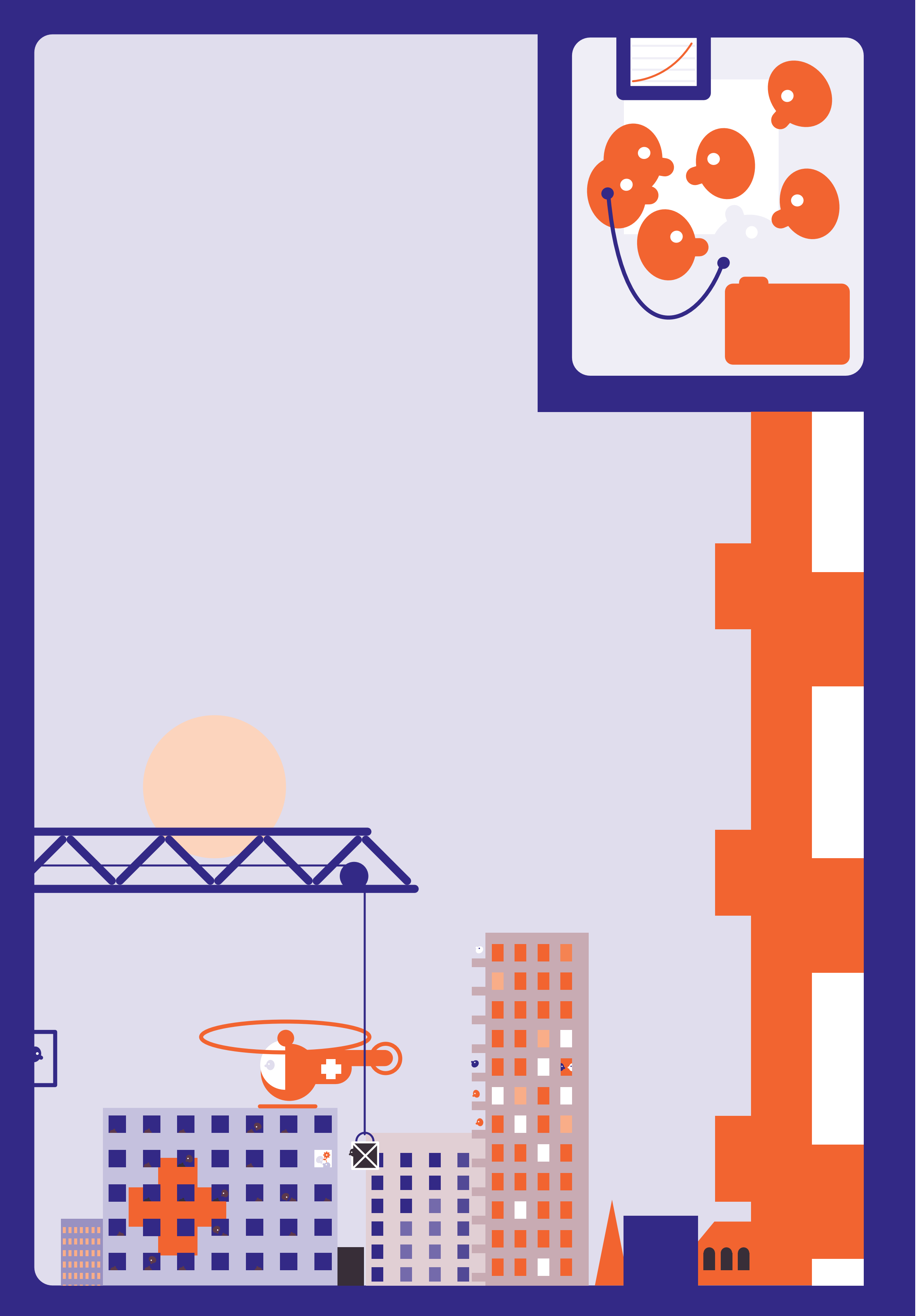
Actor closeness centrality is calculated as $CC\ (n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1}$

where $d(n_i, n_j)$ is a distance function which captures the length of the geodesics from actor i to actor j[20]. We standardized this index with $(g-1)\ CC\ (n_i)$ (where g is the group size) and used it to test Hypothesis 4.

References

1. Richardson WC. *Crossing the quality chasm: A new health system for the 21st century.* Washington DC: National Academy Press; 2001.
2. Hartman M, Martin A, McDonnell P, Catlin A. National health spending in 2007: Slower drug spending contributes to lowest rate of overall growth since 1998. *Health Aff (Millwood).* 2009;28:246-61.
3. Berwick DM. Disseminating innovations in health care. *JAMA.* 2003;289:1969.
4. Kuttner R. Market-based failure - a second opinion on U.S. health care costs. *N Engl J Med.* 2008;358:549-51.
5. Herzlinger R. Why innovation in health care is so hard. *Harv Bus Rev.* 2006;84:58-66.
6. Controller's report. Training expenditures. *Cont Rep.* 2006:13-4.
7. Corporate Training & Development. The latest metrics on learning hours, training costs & more. *HR Focus.* 2008;85:6-7.
8. Arthur J, Bennett J, Edens P, Bell S. Effectiveness of training in organizations: A meta-analysis of design and evaluation features. *J Appl Psychol.* 2003;88:234-45.
9. Aguinis H, Kraiger K. Benefits of training and development for individuals and teams, organizations, and society. *Annu Rev Psychol.* 2009;60:451-74.
10. Meyers P, Sivakumar K. Implementation of industrial process innovations: Factors, effects, and marketing implications. *J Prod Inn Man.* 1999;16:295-311.
11. Steinert Y, Mann K, Centeno A, Dolmans D, Spencer J, Gelula M, et al. A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME guide no. 8. *Med Teach.* 2006;28:497-526.
12. Rubak S, Mortensen L, Ringsted C, Malling B. A controlled study of the short- and long-term effects of a train the trainers course. *Med Educ.* 2008;42:693-702.
13. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
14. Larsen G, Ballal T. The diffusion of innovations within a UKCI context: An explanatory framework. *Cons Man & Econ.* 2005;23:81-91.
15. Rogers EM. *Diffusion of innovations.* New York: Free Press; 2003.
16. Sibthorpe B, Glasgow N, Wells R. Emergent themes in the sustainability of primary health care innovation. *Med J Austr.* 2005;183:S77-80.
17. Wejnert B. Integrating models of diffusion of innovations: A conceptual framework. *Ann Rev Soc.* 2002;28:297-326.
18. Boulay M, Storey JD, Sood S. Indirect exposure to a family planning mass media campaign in nepal. *J Health Comm.* 2002;7:379-99.
19. Valente T, Fosados R. Diffusion of innovations and network segmentation: The part played by people in promoting health. *Sex Transm Dis.* 2006;33:S23-31.
20. Wasserman S, Faust K. *Social network analysis.* Cambridge: Cambridge University Press; 1994.
21. Tenkasi R, Chesmore M. Social networks and planned organizational change. *J Appl Behav Sci.* 2003;39:281.
22. Hansen M. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Org Sci.* 2002;13:232-48.

23. Björk J, Magnusson M. Where do good innovation ideas come from? exploring the influence of network connectivity on innovation idea quality. *J Prod Inn Man*. 2009;26:662-70.
24. Burt R. Structural holes and good ideas. *Am J Soc*. 2004;110:349-99.
25. Granovetter M. The impact of social structure on economic outcomes. *J Econ Perspect*. 2005;19:33-50.
26. West E, Barron DN. Social and geographical boundaries around senior nurse and physician leaders: An application of social network analysis. *Can J Nurs Res*. 2005;37:132-48.
27. Coleman JS, Katz E, Menzel E. *Medical innovation: A diffusion study*. New York, NY: The Bobbs-Merrill Company, Inc; 1966.
28. Fattore G, Frosini F, Salvatore D, Tozzi V. Social network analysis in primary care: The impact of interactions on prescribing behaviour. *Health Pol*. 2009;92:141-8.
29. Reagans R, McEvily B. Network structure and knowledge transfer: The effects of cohesion and range. *Adm Sci Q*. 2003;48:240-67.
30. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach*. 2008;30:248-53.
31. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach*. 2007;29:642-7.
32. Royal Dutch Medical Association - Koninklijke Nederlandsche Maatschappij tot Bevordering der Geneeskunst. Resolution (kaderbesluit) CCMS 2004. *Staatscourant*. 2004;Febr 9 2003.
33. Norcini J, Blank L, Duffy FD, Fortna G. The mini-CEX: A method for assessing clinical skills. *Ann Intern Med*. 2003;138:476-81.
34. In-VIVO project. Implementation project in-VIVO starts october 17th 2006. *http://www medischevervolgopleidingen nl*. 2006.
35. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication*. Oxford: Oxford University Press; 2003.
36. Kratzer J. *Communication and performance.* Groningen: ICS; 2001.
37. Borgatti SP, Everett MG, Freeman LC. *Ucinet 6 for windows*. Needham, MA: Analytic Technologies; 2002.
38. Antonucci T. Social relations: An examination of social networks, social support, and sense of control. In: Birren J, Schaie KW, editors. Handbook of the psychology of aging (5th ed.). San Diego, CA, US: Academic Press; 2001. p. 427-53.
39. Kunst L, Kratzer J. Diffusion of innovations through social networks of children. *Young Cons*. 2007;8:36-51.
40. Ajrouch K, Blandon A, Antonucci T. Social networks among men and women: The effects of age and socioeconomic status. *J Ger Ser B: Psych Sci & Soc Sci*. 2005;60:311-7.
41. Garcia-Goni M, Maroto A, Rubalcaba L. Innovation and motivation in public health professionals. *Health Pol*. 2007;84:344-58.
42. Weick C, Martin J. Full-time and part-time independent inventors: Rising with the creative class. *Int J Entr & Inn*. 2006;7:5-12.
43. Storey J, Quintas P, Taylor P, Fowle W. Flexible employment contracts and their implications for product and process innovation. *Int J Hum Res Man*. 2002;13:1-18.
44. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man*. 2001;19:1-12.
45. Grant R. *Contemporary strategy analysis: Concepts, techniques, applications*. Malden MA: Blackwell Publishers; 2001.
46. Snijders TAB, Bosker RJ. *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London: Sage Publications Ltd; 1999.
47. Maas C, Hox J. Sufficient sample sizes for multilevel modeling. . 2005;1:86-92.
48. Miles J, Shevlin M. *Applying regression and correlation: A guide for students and researchers*. London: SAGE Publications Ltd; 2001.
49. Field A. *Discovering statistics using SPSS (and sex, drugs and rock 'n' roll)*. London: AGE Publications Ltd; 2005.
50. Cohen J, West SG, Cohen P. *Applied multiple regression: Correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum Associates; 2002.
51. Kirkpatrick D, Kirkpatrick J. Prepare for evaluation. *Lead Exc*. 2006;23:13-.
52. Baregheh A, Rowley J, Sambrook S. Towards a multidisciplinary definition of innovation. *Man Dec*. 2009;47:1323-39.



Chapter 6

Applying social network analysis to explain clinical teaching behavior: exploratory study

Erik Jippes
Yvonne Steinert
Jan Pols
Marjolein C. Achterkamp
Jo M.L. van Engelen
Paul L.P. Brand

Submitted

Abstract

Objectives: To examine the importance of social networks and a 2-day faculty development workshop on adoption of an educational innovation – structured and constructive feedback – by clinical supervisors.

Methods: We administered a validated questionnaire to residents (n = 357) and clinical supervisors (n = 370) of different specialties (anesthesiology, radiology, pediatrics, and obstetrics/gynecology) in the Netherlands. Residents were asked to rate the clinical supervisors' adoption of an educational innovation, the use of "structured and constructive feedback". Clinical supervisors also performed a self-assessment of their adoption of the feedback innovation and rated their communication intensity with fellow clinical supervisors in their teams, resulting in a centrality score (the extent to which an individual is connected to colleagues in the network of his or her own clinical team) of the clinical supervisor. The effects of supervisor centrality and participation in a 2-day Teach-the-Teacher faculty development course on the degree of adoption of structured feedback were analyzed using hierarchical linear modeling, adjusting for age, gender, and attitude towards educational innovation in general.

Results: Although the Teach-the-Teacher course was significantly related to the supervisors' self-assessment of innovation adoption (p = .013), following such a course had no effect on the residents' ratings of the supervisors' adoption of structured feedback (p = .272). In contrast, supervisor social network centrality was significantly related to adoption of the educational innovation, both in the residents' assessment (p = .023) and in the self-assessment (p = .024).

Conclusions: A clinical supervisor's social network may be as least as important in the adoption of an educational innovation as participation in a medical faculty development course. Faculty development programs should consider using faculty members' social networks to improve the adoption of educational innovations and to help build and maintain communities of practice.

Keywords: Evaluation/assessment of clinical performance, Faculty development, Quantitative research methods, Postgraduate training, Clinical education.

Table 1

Pendleton's rules of feedback

- The feedback is structured
- The supervisor gives the trainee (resident) the opportunity to give his/her opinion on his/her performance
- The supervisor provides points that went well
- The supervisor specific points for improvement
- The supervisor provides the feedback in a constructive and supportive ("safe") fashion

Introduction

Although the theoretical framework of experiential learning theory has been widely accepted and supported by observational empirical data[1], almost all efforts to improve the educational knowledge and skills of medical specialists, residents, medical students and house officers comes in the form of workshops, courses, and seminars[2]. And there is a remarkable paucity of experimental studies documenting the effects of such educational interventions on the professional behavior of medical faculty involved in clinical teaching. A systematic review[3] indicated that faculty development activities were highly valued by participants, who also reported a positive change in attitude towards teaching in general, and improvements in educational knowledge, self efficacy, and behavior. Interestingly, however, the behavioral changes perceived by participants were not consistently reflected in student (or resident) evaluations of the participants' teaching, and few effects on student behavior were demonstrated[3]. Apparently, it is necessary to explore additional factors to faculty development activities that affect the transfer of knowledge and skills into clinical teaching practice. Ample evidence is available from research in business and management, and from studies on the implementation of health care technologies, suggesting that social networks may be such an additional factor and a promising field of research in determining the degree of adoption of educational innovations[4,5].

Social networks function as channels for communication, social construction, and negotiation of an innovation, and can increase the observability of the innovation, thereby reducing the novelty and uncertainty of the outcomes of the innovation for the potential adopters[4,5]. Based on the principle that the pattern of relations among individuals and groups of people influences outcomes over and above the attributes of the individuals and the group alone, social network analysts have examined the effects of connections between individuals in networks on the adoption of innovations[6]. A key variable in such network research is the extent to which an individual is connected to other actors in the network, referred to as centrality[7]. Individuals with high centrality are significantly more likely to be promoted in business organizations[8]. Similarly, the degree of students' centrality in their networks is associated with their enjoyment of learning and their academic success[6]. To our knowledge, the importance of social networks in understanding the adoption of innovations in medical education and the impact of faculty development activities has not been studied to date. With the increasing number of educational innovations being implemented in graduate and Postgraduate Medical Education (PGME) programs, analyzing factors associated with successful implementation of innovation in medical education is warranted.

In 2004, the Royal Dutch Medical Association - Central College for Medical Specialists (CCMS) - issued a legal directive requiring all medical specialist societies in the Netherlands to renew their PGME programs for residents[9], based on the CanMEDS framework of core competencies[10]. One of the key recommended changes was the introduction of structured and constructive feedback, based on Pendleton's rules (as outlined in Table 1)[11].

Before 2004, feedback in PGME, if offered at all, was given in an unstructured and sometimes derogatory manner[12,13]. More recently, in a pilot project related to the implementation of new PGME programs, both residents and clinical supervisors expressed the view that the introduction of such structured and constructive feedback was the most important innovation in the renewed PGME curricula[14]. To help clinical supervisors to master the skill of structured and constructive feedback, and to improve its implementation in clinical practice, 2-day Teach-the-Teacher (TtT) courses were developed and offered to clinical supervisors from 2004 onwards. Participation in these courses was recommended and supported by the government as the renewal of the PGME programs was to be completed by the end of 2010[9].

We designed this study to explore the effects of centrality (of the clinical supervisor in his/her social network with peer clinical supervisors) on the degree of adoption of an educational innovation (i.e., structured and constructive feedback) by clinical supervisors, by examining the direct effects of centrality on adoption and by looking at the effects of centrality as compared to participation in a faculty development program (the 2-day TtT course).

Methods

Study subjects

Between 2007 and 2010, teams of residents and clinical supervisors from surgical (obstetrics/gynecology), medical (pediatrics), diagnostic (radiology) and supportive (anesthesiology) disciplines, both in university and general hospitals involved in clinical teaching of residents, were recruited for this study.

Study questionnaire (dependent variables)

In 2009-2010, the residents and clinical supervisors from the four medical disciplines were asked to complete a previously validated questionnaire to assess their degree of adopting "structured and constructive feedback"[15]. We used Rogers' definition of adoption: "the decision to make full use of an innovation as the best course of action available"[5], adjusted slightly to the context of our innovation studied. We believe that the adoption of "structured and constructive feedback" can not be stated in a simple yes or no, it is more a matter of degree of adoption.

Residents were asked to assess the nature of the feedback given by their clinical supervisors in the six months before the questionnaire was administered. For each supervisor they encountered during this 6-month period, they were asked to rate each of the five components of Pendleton's feedback rules as provided by their clinical supervisor on a 5-point Likert scale, ranging from "totally disagree" to "totally agree", including the possibility to assign "not possible to assess this supervisor". The items were being worded as "the supervisor provides feedback in a structured way", "the supervisor gives me the opportunity to give my opinion on my performance", etc., (see Table 1). The mean Likert score on the five items was used as the clinical supervisor's innovation adoption score. Only clinical supervisors who had been assessed by at least two residents were included in the data analysis, and their mean innovation adoption score was used as the dependent variable in analyses.

Clinical supervisors completed a similar questionnaire rating their own adoption of the innovation "structured and constructive feedback" with Likert-scale questions on the five items of Pendleton's rules (Table 1). They also rated the question "Structured feedback constitutes an improvement of the quality of the clinical teaching of residents" on a 5-point Likert scale ranging from "totally disagree" to "totally agree", as a measure of their attitude towards the renewal of the PGME programs. We controlled for this variable because the adopter's attitude may have an effect on innovation adoption[16].

Teach-the-Teacher course (independent variable)

The TtT course comprised 2-day training in structured and constructive feedback, use of the Mini-CEX, and adult learning principles[17]. Clinical supervisors from different specialties and hospitals in the Netherlands were invited to participate in these TtT courses,

Table 2

Descriptive characteristics of study sample of 370 medical specialists

Male gender (%)	261 (62.4%)
Teach-the-Teacher course followed (%)	172 (46.5%)
Mean age, years (SD)	46.8 (8.4)
Overall attitude towards innovation of education*, mean (SD)	
Radiologists (n=210)	4.20 (0.92)
Anesthesiologists (n=75)	4.33 (0.72)
Gynecologists (n=42)	4.32 (0.75)
Pediatricians (n=43)	4.51 (0.63)
Innovation adoption score – self-assessment, mean (SD)**	4.11 (0.57)
Innovation adoption score – resident assessment, mean (SD)	4.06 (0.47)
Centrality of supervisor in social network, mean (SD)***	37.9 (31.2)

* Response to statement "Structured feedback constitutes an improvement of the quality of the clinical teaching of residents" on a 5-point Likert scale, ranging from totally disagree (scored as 1) to totally agree (scored as 5)

** Mean Likert scale score on the use of the 5 items of Pendleton's rules (Table 1) in feedback

*** Represents the percentage of fellow clinical supervisors he or she has contact with – about new developments – at least once a month

including the clinical supervisors in our sample. We examined whether participation in the TtT course in the three years prior to the questionnaire had any impact on adoption of the innovation "structured and constructive feedback".

Network analysis (independent variable)

We used a "full roster design". Following standard practice for network analysis[7], each clinical supervisor received a list with all names of their fellow clinical supervisors in their department, and was asked to rate the communication intensity, by answering the question "how often do you communicate with your fellow clinical supervisors in the past half year about the introduction of innovations, new methods or procedures, or new developments related to the work situation? on a 6-point scale ranging from "never," (scored as 1) to "less than once a month", "more than once a month", "weekly", "daily", or "more than once daily" (scored as 6). The centrality score of a clinical supervisor represents the percentage of fellow clinical supervisors he or she has contact with at least once a month. The index thus ranges from 0 (the clinical supervisors has no contact about new developments with other supervisors in the department) to 100 (the supervisor has contact with all supervisors in the department on at least a monthly basis). Details of the network analysis and calculation of centrality are presented in the appendix.

Statistical analysis

First, the effects of following a TtT course and centrality on innovation adoption scores were assessed using t-tests and correlation analyses. Subsequently, we analyzed the independent effects of following a TtT course and centrality on innovation adoption after adjusting for age, gender, and attitude towards renewed PGME. To account for the nested structure of the data (individuals within teams), two-level hierarchical linear modeling was used for this purpose[18]. We inserted the interaction effects between the TtT and centrality index to assess possible moderating effects.

Results

Study subjects

The total sample included 613 clinical supervisors (370 radiologists, 50 gynecologists, 46 pediatricians, and 147 anesthesiologists) and 571 residents (344 in radiology, 50 in gynecology, 36 in pediatrics, and 141 in anesthesiology) from 38 teams (24, 4, 5, and 5, respectively). From the total sample of 613 clinical supervisors, 420 responded

Figure 1

Figure 1a
Small gynecology department (n = 6)

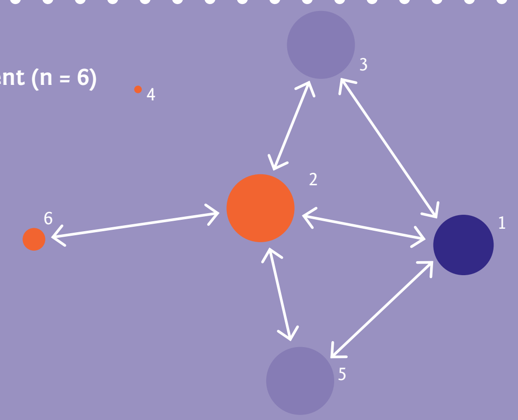
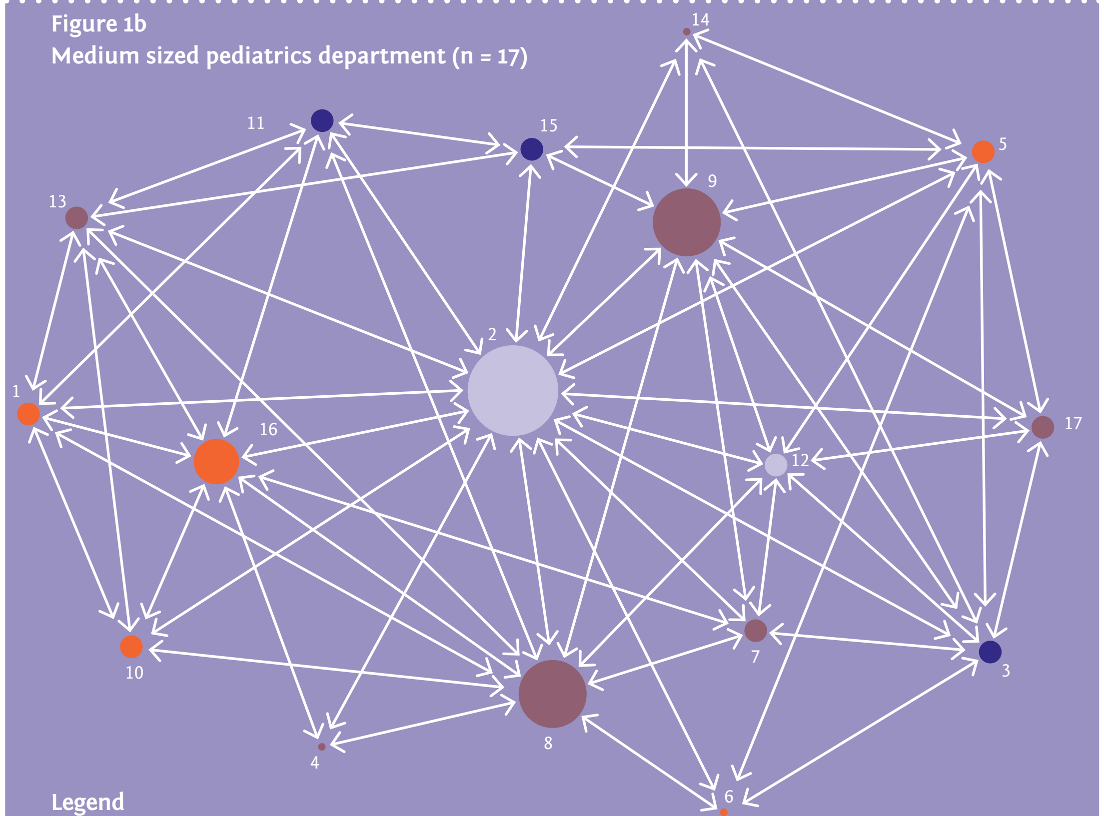


Figure 1b
Medium sized pediatrics department (n = 17)



Legend
The circles represent clinical supervisors. The size represents the centrality of the supervisor. The lines represent communication about new developments on at least a monthly basis. The color shows the adoption pattern (resident assessment), red represents the first quartile (score between 1.90 - < 3.80), purple represents the second quartile (3.80 - < 4.10), blue the third quartile (4.10- < 4.40) and light blue the fourth quartile (4.40 - 5.00).
continuation on page 192

to the questionnaire (69%). After discarding questionnaires with incomplete answers, responses from a total of 370 (210 radiologists, 42 gynecologists, 43 pediatricians, and 75 anesthesiologists) were analyzed. From the total sample of 571 residents, questionnaires from 357 respondents (63%) (210 in radiology, 41 in obstetrics/gynecology, 23 in pediatrics, and 98 in anesthesiology) were included (see Table 2 for descriptive statistics).

Univariate analyses "Teach-the-Teacher" and "Centrality"
Clinical supervisors who had followed a TtT course in the past three years (n = 172) had a mean (SD) self-assessment innovation adoption score of 4.20 (.55), as compared to 4.02 (.58) for those who had not followed such a course (n = 198; 95% confidence interval [CI] for difference .06 to .30, *p* = .013). The residents' mean (SD) assessment of their supervisors' innovation adoption was 4.04 (.50) for the supervisors who had followed a TtT course, and 4.07 (.45) for those who had not (95% CI –.07 to .13, *p* = .272).

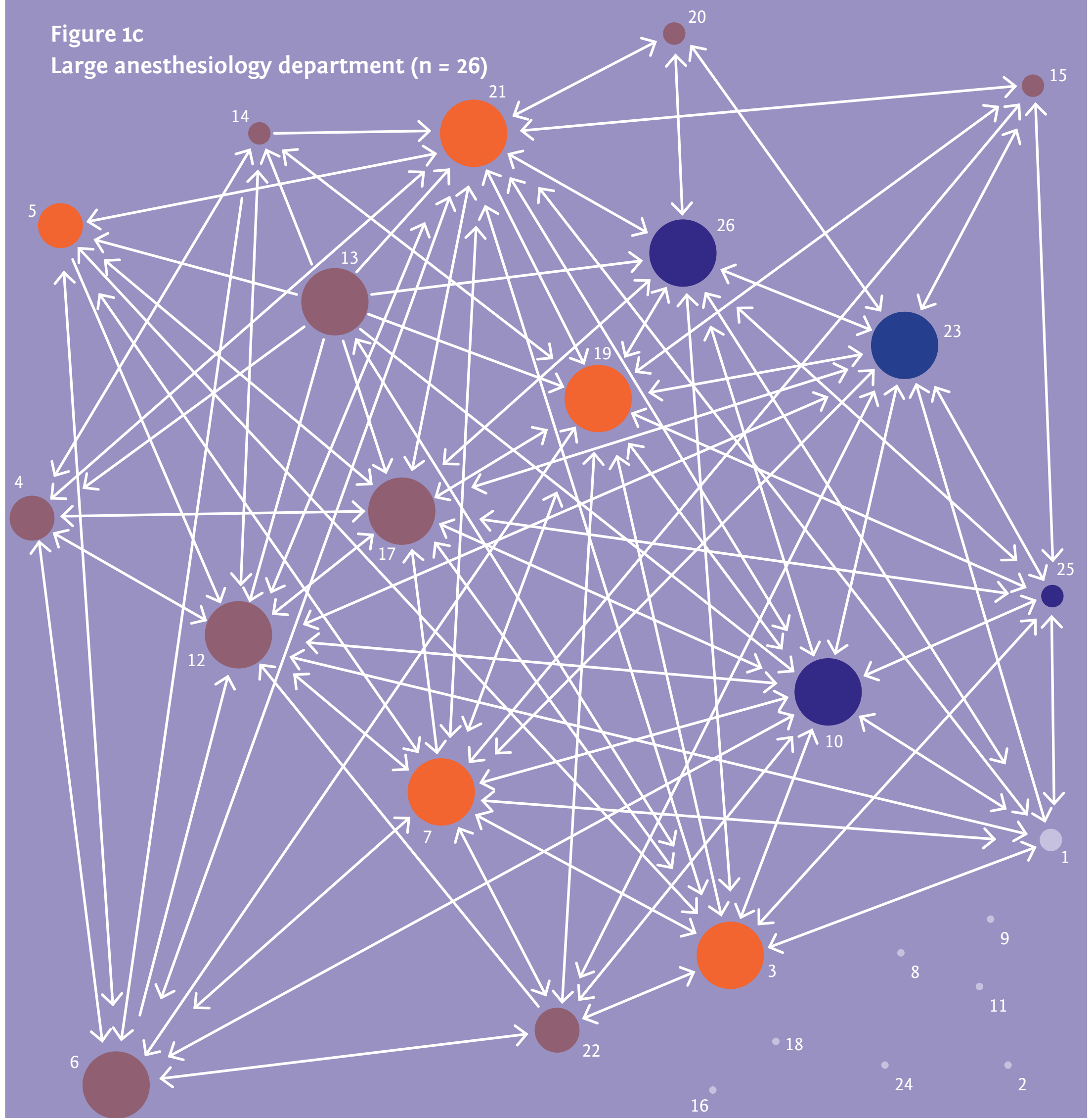
Clinical supervisors in the highest quartile of the centrality score (score of 58.33 or higher, n = 93) had a mean (SD) self-assessment innovation adoption score of 4.19 (.53), as compared to 3.96 (.64) for those in the lowest quartile of centrality scores (lower than 13.33) (n = 86; 95% CI for difference -.41 to -.06, *p* = .004). The residents' mean (SD) assessment of their supervisors' innovation adoption was 4.11 (.46) for the supervisors in the highest quartile of centrality scores, and 3.99 (.47) for those in the lowest quartile (95% CI -.25 to .02, *p* = .048). Figure 1 presents several examples of social networks of medical specialists, including the centrality of the medical specialists and their adoption score to demonstrate the principle graphically.

Univariate analyses control variables
The correlation between the clinical supervisors' self-assessment and the residents' scores was considerably higher for those supervisors who had followed a TtT course than for those who had not (Figure 2).

There were no significant differences in gender, age, and attitude towards renewal of PGME between participants and non-participants of the TtT course (all *p* values > .4). Resident assessment of innovation adoption by supervisors was significantly correlated to supervisor's age (*r* = -.14, *p* = < .001). Male supervisors

Figure 1 *continuation*

Figure 1c
Large anesthesiology department (n = 26)



Legend
The circles represent clinical supervisors. The size represents the centrality of the supervisor. The lines represent communication about new developments on at least a monthly basis. The color shows the adoption pattern (resident assessment), ● red represents the first quartile (score between 1.90 - < 3.80), ● purple represents the second quartile (3.80 - < 4.10), ● blue the third quartile (4.10- < 4.40) and ● light blue the fourth quartile (4.40 - 5.00).

(n = 261) rated their own innovation adoption significantly higher (mean score 4.16, SD .57) than female supervisors (n = 109, mean 3.98, SD .57, p = .006). Supervisor's self-assessed innovation adoption score was significantly correlated to attitude (r = .23, p = < .001) and centrality (r = .14, p = .006). Male supervisors in our group were significantly older (mean 47.87, SD 8.51) than female supervisors (mean 44.06, SD 7.47, p < .001). Finally, male supervisors had a significantly higher centrality (mean 42.93, SD 31.69) than female supervisors (mean 25.69, SD 26.18, p < .001).

Multivariate analyses

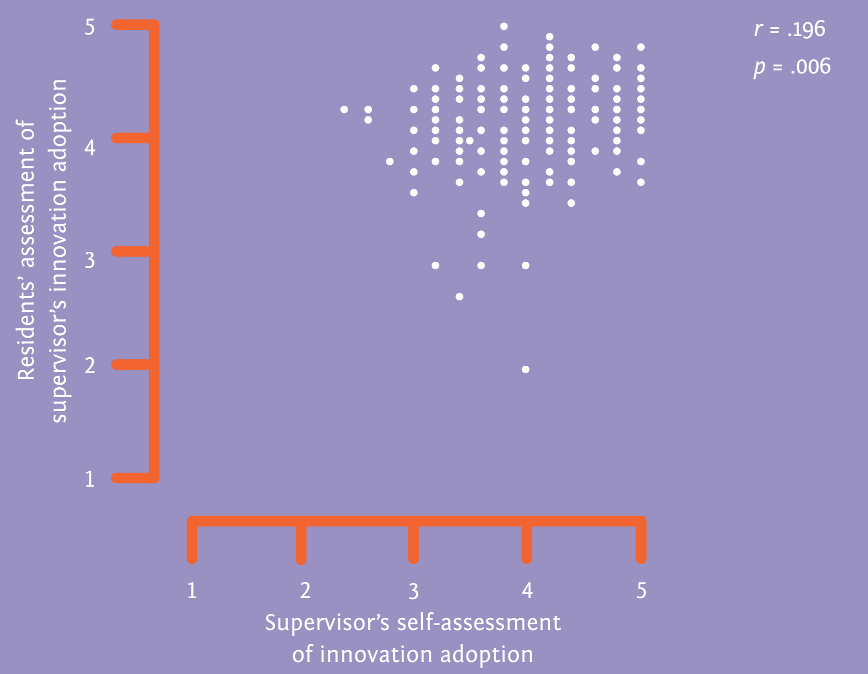
The results of the hierarchical linear model are presented in Tables 3 and 4. The model showed variance on both levels (individual and department). In the multivariate models, all three control variables significantly influenced innovation adoption scores: male supervisors had higher scores than female supervisors, innovation adoption was inversely related to increasing age of the supervisor, and there was a positive relationship between supervisor attitude towards renewal and adoption of the innovation "structured and constructive feedback". After adjusting for these control variables, following a TtT course was weakly but significantly related to supervisor's self-assessment of innovation adoption (explained variance 11.49% on the individual level), but not to the residents' evaluation of their supervisor's adoption of structured feedback. In contrast, clinical supervisor centrality was significantly related to innovation adoption as rated both by the residents (explained variance 4.15%) and by the supervisors themselves (explained variance 9.29%) (Tables 3 and 4). There was no significant interaction between the TtT course and clinical supervisor centrality in any of the models.

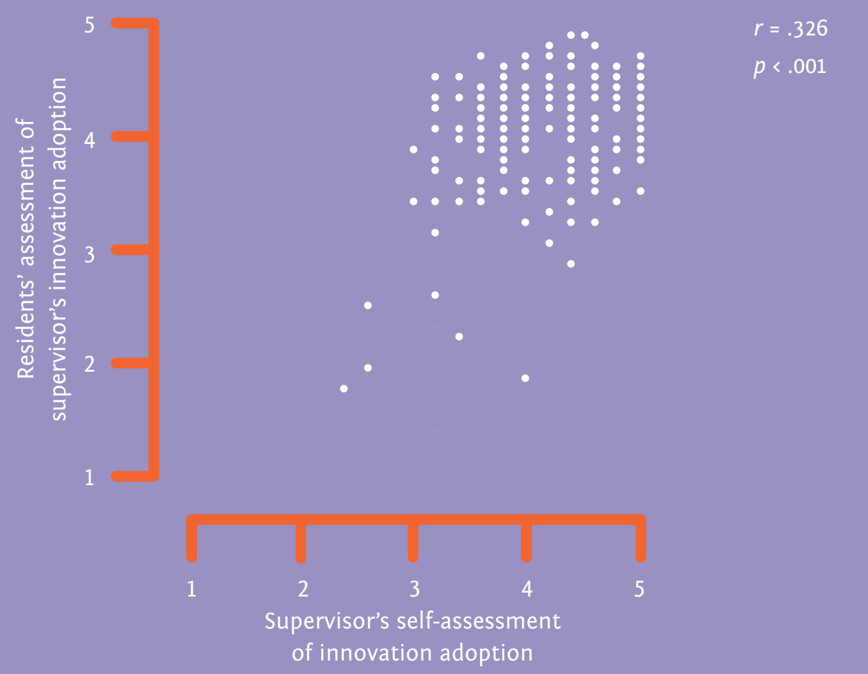
Discussion

This study compared the effects of Teach-the-Teacher training and social networks on the adoption of an innovation in clinical medical education (providing structured and constructive feedback to residents). Although having followed a TtT course significantly increased supervisors' self-assessment of the use of the novel feedback technique, it had no perceived effect on the residents' ratings of the supervisors' innovation adoption (as measured in this study). In contrast, the centrality of the clinical supervisor within the social network of his or her own clinical team was significantly related to innovation adoption both in the residents' assessment and in the self-assessment. These associations remained significant after

Figure 2

Scatter plot residents' assessment and self-assessment of innovation adoption for supervisors who followed a Teach-the-Teacher course (top panel) and those who did not (panel below)





adjustment for supervisor's age, gender, and attitude towards renewal of PGME. These results suggest that faculty development providers should not only develop educational interventions, but should also take the faculty members' social networks into account.

The importance of social networks in business innovations has been recognized by business innovators and researchers for many years[5]. The degree to which an individual in a social network is connected to other individuals in the network (actor centrality) has been shown to have a major influence on the adoption of business innovations by that particular individual[5,19]. Social network analysis has also been applied in studies on the implementation of health care technologies[4], and a recent publication suggested that a network approach towards faculty development might be important in determining its success[20]. To our knowledge, however, our study is the first to examine the effects of social networks on the adoption of an innovation in medical education.

In line with previous studies[2,3], the effect of training such as our 2-day Teach-the-Teacher course on professional teaching behavior is limited. This does not mean that such educational workshops and courses should be abandoned, especially as they are effective methods to disseminate information to groups of individuals. Based on our results, however, we recommend that such courses should be designed to contain a large proportion of interactive exercises, such as role play and discussions, not only because such active participation is likely to improve the retention of knowledge and skills by participants[21], but also because the interaction between individual participants is likely to engage social network structures between participants in different departments (in case of participants of different departments/specialties) and within departments (in case of participants of the same department/specialty). This engaging of social network structures may also explain why long-term, comprehensive faculty development programs appear to be more successful than isolated workshop interventions[3]. Several recent articles have also highlighted the role of social practices in faculty development and the importance of faculty development in building communities of practice[22,23]. Our findings support the notion of looking at faculty development through this lens and moving beyond workshops as the only method of delivery[22].

Table 3

Hierarchical linear model for supervisor innovation adoption – resident assessment

Variable*	Regression coefficient (SE)	P Value
Gender (male is reference category)	-.043 (.052)	.206
Age	-.008 (.003)	.002
Attitude	.045 (.028)	.054
Teach-the-Teacher training	-.016 (.048)	.371+
Supervisor centrality	.001 (<.000)	.023†

* The control variables were entered as one group into the analyses. Teach-the-Teacher training and supervisor centrality were assessed independently of each other, together with the control variables

\+ R^2 = 2.92% on the individual level

† R^2 = 4.15% on the individual level

Table 4

Hierarchical linear model for supervisor innovation adoption – self-assessment

Variable*	Regression coefficient (SE)	P Value
Gender (male is reference category)	-.195 (.065)	.001
Age	.004 (.004)	.159
Attitude	.167 (.035)	.<000
Teach-the-Teacher training	.180 (.058)	.001+
Supervisor centrality	.002 (.001)	.024†

* The control variables were entered as one group into the analyses. Teach-the-Teacher training and supervisor centrality were assessed independently of each other, together with the control variables

\+ R^2 = 11.49% on the individual level

† R^2 = 9.29% on the individual level

It is also interesting to note that clinical supervisors were significantly more likely to consider themselves as successful adopters of structured and constructive feedback than their residents, and the effects of having followed a TtT course on the adoption of the educational innovation was only demonstrated in the supervisors' self-assessment, and not in the residents' assessment of their supervisors. Apparently, supervisors overrate their own adoptive behavior. This is consistent with earlier studies showing that adult learners perform relatively poorly in assessing their own clinical (or educational) competence[24]. Alternatively, residents may not recognize feedback when it is given, often confusing feedback with teaching[25,26].

We examined the influence of three potential confounding factors in our study. Clinical supervisors were less likely to show adoptive behavior with increasing age. Although it would be tempting to conclude that older faculty members are less able to learn new skills or less willing to adopt them[27], two alternative explanations should be considered. First, residents may be more likely to identify with younger clinical supervisors. Secondly, younger faculty may already have been more familiar with structured and constructive feedback than their older colleagues because their own medical training was already more oriented towards this innovation. Not unexpectedly, clinical supervisors with a more positive attitude towards medical educational innovation in general were more likely to adopt and apply structured and constructive feedback, according to their self-assessment. This is in agreement with research on attitude and innovation adoption in health care[16]. According to the residents, male supervisors performed better on the adoption of structured feedback than female supervisors. The fact that gender was only of borderline significance in the multivariate analysis (Table 3) suggests that this may be partly due to the stronger embeddedness of males than females in their respective social networks. Their higher centrality may have given men more opportunities than women to get acquainted with and adopt the innovation.

Our results on centrality confirm the social capital benefits individuals may gain from holding central network positions in other contexts. A meta-analysis of eight studies found that high centrality individuals are likely to emerge as leaders, to be more satisfied, and to participate more in task solutions in businesses[28]. Other studies showed that centrality independently predicted individuals' workplace performance[29], and that high centrality increases the likelihood of employees to remain in their positions[30]. In an advertising and public relations agency, centrality was found to be the most significant predictor for innovation involvement[19]. Individuals who are more central have more opportunities to hear and see new ideas, avail themselves of the necessary resources for implementation, and adopt the innovation[4].

Strengths, limitations and suggestions for further research

This study is the first to compare the effects of TtT training and social networks on the implementation of a medical educational innovation. The use of both residents' assessments and self-assessments, and the large study sample allowing for hierarchical linear modeling, improve the robustness of our findings.

This study had a number of limitations. First, our explained variance was relatively low, which means that there were variables beyond the scope of our study which had significant effects on innovation adoption. Second, the adoption of the educational innovation may have been influenced by other social networks that remained uninvestigated, for example with supervisors from other departments or hospitals, or with medical educationalists. It is likely that such interdisciplinary collaboration increases the likelihood of innovation adoption, but this requires further study in the area of medical education. Third, this study was set up as an exploratory study with a cross-sectional and observational research design. Longitudinal and more experimental approaches, including pre- and posttest, are needed to study the dynamics of social networks in PGME innovation, and to test the hypothesis that such networks are indeed important. Fourth, we measured the effect on innovation adoption of clinical supervisors having followed a TtT course in the three years prior to the questionnaire. The fact that the period between the course and the questionnaire was different for the supervisors in our sample may have impacted the results. Finally, our study was limited to the implementation of structured and constructive feedback in four disciplines of PGME in the Netherlands. This can be called a genuine innovation, as this change was "new" for the adopting organization[5]. However, caution is required in generalizing our findings to other types of innovations and organizations.

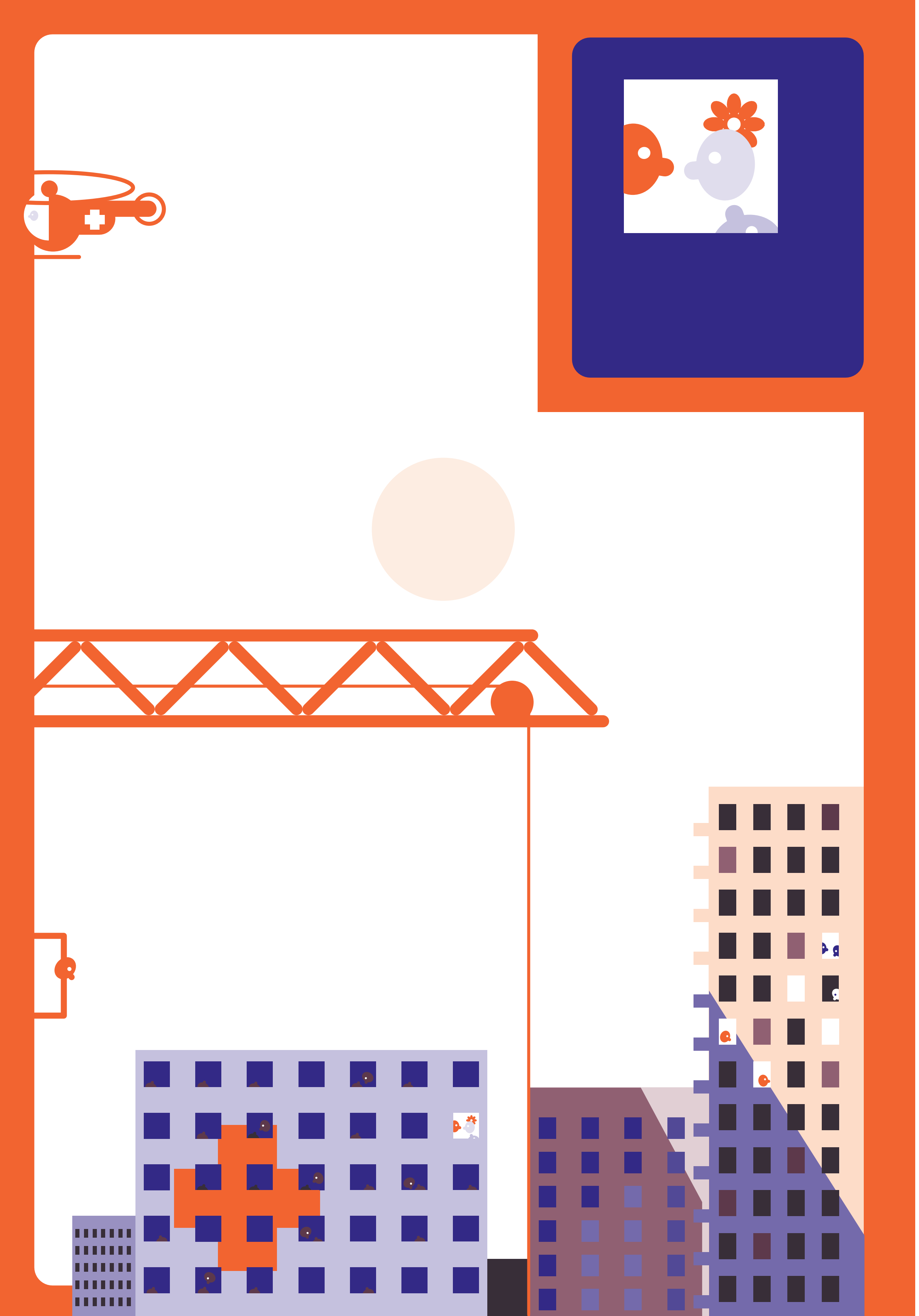
Although further studies are now needed to corroborate our findings, our results may be viewed as a demonstration of the principle that the structure of a clinical supervisor's social network may be at least as important in the adoption of new pedagogical methods as educational courses in medical faculty development. Our results also suggest that faculty development should not only consist of educational workshops and courses, but could capitalize on faculty members' social networks to improve the implementation of innovations in medical education. This may be accomplished by using diverse strategies, such as specifically including medical faculty with high centrality in faculty development initiatives, and by approaching faculty development initiatives as key components in building – and maintaining – communities of practice.

Appendix: Network analysis and calculation of centrality

The answers given by the respondents resulted in a directed valued matrix. "Directed" means that the tie of one person to another has a direction. Each clinical supervisor filed some communication intensity score for each of their fellow clinical supervisors. The answers for clinical supervisor *i* to clinical supervisor *j* may not be the same as the answers for clinical supervisor *j* to *i*. "Valued" means that the tie can range between "never" (score 1), "less than once a month" (score 2), "more than once a month" (score 3), "weekly" (score 4) "daily" (score 5), and "more than once daily" (score 6). In order to compute centrality, the data needed to be transformed into an undirected dichotomous matrix. We used the maximum symmetrizing method to convert the directed matrix into an undirected one and to correct for missing network data. This meant that the highest rating of communication intensity between two persons was used or, in the case of missing network data, the rating from one person. To dichotomize the undirected valued matrix (ranging from 1 to 6), we recoded the scores as follows. The values one and two were recoded into zero, which means there is no communication. The values three, four, five and six were recoded into one, which means there is a communication relationship between clinical supervisors. We chose this cut-off point because even weakly connected social networks (beginning with score three) produce considerable effects. For each clinical supervisor, degree centrality was computed as = $x_{i+} = \sum_j x_{ij} = \sum_j x_{ji}$ where x_{ij} is the direct contact from clinical supervisor *i* to clinical supervisor *j*[7].

References

1. Kolb DA. *Experiental learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall; 1984.
2. McLean M, Cilliers F, Van Wyk JM. Faculty development: Yesterday, today and tomorrow. *Med Teach*. 2008;30:555-84.
3. Steinert Y, Mann K, Centeno A, Dolmans D, Spencer J, Gelula M, et al. A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME guide no. 8. *Med Teach*. 2006;28:497-526.
4. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q*. 2004;82:581-629.
5. Rogers EM. *Diffusion of innovations*. New York: Free Press; 2003.
6. Baldwin T, Bedell M, Johnson J. The social fabric of a team-based M.B.A. program: Network effects on student satisfaction and performance. *Acad Man J*. 1997;40:1369.
7. Wasserman S, Faust K. *Social network analysis*. Cambridge: Cambridge University Press; 1994.
8. Brass D. Being in the right place: A structural analysis of individual influence in an organization. *Adm Sci Q*. 1984;29:518-39.
9. Royal Dutch Medical Association - Koninklijke Nederlandsche Maatschappij tot Bevordering der Geneeskunst. Resolution (kaderbesluit) CCMS 2009. *Staatscourant*. 2009;Nov 18 2009.
10. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach*. 2008;30:248-53.
11. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication*. Oxford: Oxford University Press; 2003.
12. Vd Hem-Stokroos HH, Scherpbier AJ, vd Vleuten CP, De Vries H, Haarman HJ. How effective is a clerkship as a learning environment? *Med Teach*. 2001;23:599-604.
13. Busari JO, Weggelaar NM, Knottnerus AC, Greidanus PM, Scherpbier AJ. How medical residents perceive the quality of supervision provided by attending doctors in the clinical setting. *Med Educ*. 2005;39:696-703.
14. Jippes E, Luijk SJ, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Barriers and facilitators to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study. *Med Teach* in press. 2012.
15. Jippes E, Achterkamp MC, Brand PLP, Kiewiet DJ, Pols J, van Engelen JML. Disseminating educational innovations in health care practice: Training versus social networks. *Soc Sci & Med*. 2010;70:1509-17.
16. Garcia-Goni M, Maroto A, Rubalcaba L. Innovation and motivation in public health professionals. *Health Pol*. 2007;84:344-58.
17. Mann KV. Theoretical perspectives in medical education: Past experience and future possibilities. *Med Educ*. 2011;45:60-8.
18. Snijders TAB, Bosker RJ. *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London: Sage Publications Ltd; 1999.
19. Ibarra H. Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. *Acad Man J*. 1993;36:471-501.
20. Baker L, Reeves S, Egan-Lee E, Leslie K, Silver I. The ties that bind: A network approach to creating a programme in faculty development. *Med Educ*. 2010;44:132-9.
21. Ramani S, Leinster S. AMEE guide no. 34: Teaching in the clinical environment. *Med Teach*. 2008;30:347-64.
22. Steinert Y. Faculty development: From workshops to communities of practice. *Med Teach*. 2010;32:425-8.
23. Steinert Y, Macdonald ME, Boillat M, Elizov M, Meterissian S, Razack S, et al. Faculty development: If you build it, they will come. *Med Educ*. 2010;44:900-7.
24. Davis DA, Mazmanian PE, Fordis M, van Harrison R, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence: A systematic review. *JAMA*. 2006;296:1094-102.
25. Shute VJ. Focus on formative feedback. *Rev Educ Res*. 2008;78:153-89.
26. Sender Liberman A, Liberman M, Steinert Y, McLeod P, Meterissian S. Surgery residents and attending surgeons have different perceptions of feedback. *Med Teach*. 2005;27:470-2.
27. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man*. 2001;19:1-12.
28. Mullen B, Johnson C, Salas E. Effects of communication network structure – components of positional centrality. *Soc Netw*. 1991;13:169-85.
29. Mehra A, Kilduff M, Brass D. The social networks of high and low self-monitors: Implications for workplace performance. *Adm Sci Q*. 2001;46:121-46.
30. Feeley T. Testing a communication network model of employee turnover based on centrality. *J Appl Comm Res*. 2000;28:262.



Chapter 7

Impact of clinical leader centrality on followers' innovation adoption

Erik Jippes
Marjolein C. Achterkamp
Jan Pols
Marijke C. Leliveld
Paul L.P. Brand
Jo M.L. van Engelen

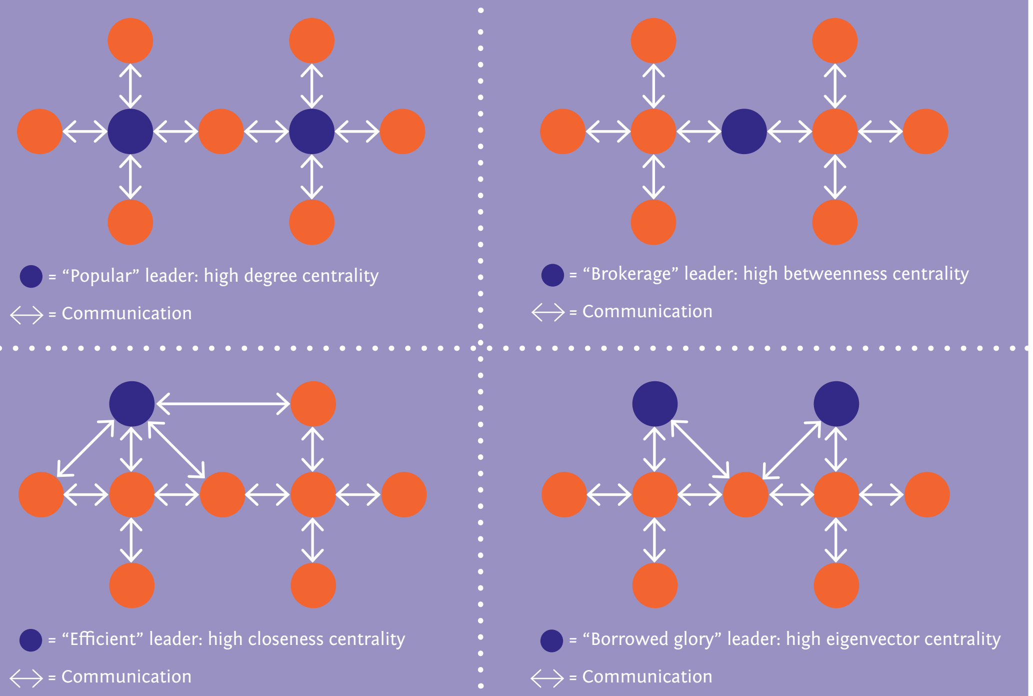
Submitted

Abstract

Leadership is considered to be one of the best predictors of innovation performance. Recently, social network ties of leaders with their followers, i.e., the structural side of social capital, have gained increased attention. Our study extends this social network research, by being the first to empirically assess the effect of four different clinical leader centralities (modeled into degree, betweenness, closeness, eigenvector centrality) on their followers' innovation adoption. We used an advanced method to gather network data, based on a questionnaire administered to 370 medical specialists who were nested in 38 teams. Results of this comprehensive and unique dataset showed that the clinical leader's degree and closeness centrality (i.e. so-called popular and efficient leaders) were positively related to follower innovation adoption. These positive associations remained significant after adjustment for age, gender, and attitude towards the innovation. Our results suggest that using leaders' social network structures may help to facilitate innovation adoption.

Keywords: Leader centrality, Social networks, Leadership, Innovation adoption, Healthcare

Figure 1
Leader centrality indices



Introduction

In recent surveys among global business executives, managers, and professionals, the respondents pointed to leadership as the best predictor of innovation adoption[1,2]. Over the years different theories, ranging from the early trait theories and contingency theories, to the more recent transformational, neo-charismatic, and information-processing theories, have tried to explain the relationship between leadership and innovation adoption[3].

The vast amount of this research, such as leader-member exchange (LMX), has focused mainly on the quality of dyadic relationships between the leader and the subordinate. However, relatively few studies have been conducted on the leaders' cognition of their wider social networks, and on the influence that the structure of the leaders' ties with their team members has on innovation adoption of their followers. This is remarkable because social networks have been widely recognized as powerful conduits for the transfer of information about innovations[4].

A key variable in the structure of the leader's ties is leader centrality: the extent to which he or she is connected to his or her team members[5]. In the past, different types of leader centralities have been defined (see Figure 1 for four examples). Although these originated from the same concept of centrality, evidence suggests that they do represent distinct facets of centrality (e.g.[6]). However, it is still unclear which type of leader centrality has most effect on innovation adoption. This is mainly caused by the fact that in past research, the different leader centralities were studied in isolation.

Our study aims to fill this gap by studying simultaneously the empirical application of four leader centralities (degree, betweenness, closeness and eigenvector) to followers' innovation adoption in a professional bureaucracy, that is, the medical community in the hospital. Peer social networks play an important role in clinical leadership[7], making the medical community a well-suited environment of investigation. We set up a multi-level study and gathered comprehensive network data from 38 teams with 370 medical specialists from different hospitals and different medical specialties, allowing us to test the individual contribution of the leader centralities in one study. Our results therefore extend previous research on leader centrality and its influence on follower innovation adoption.

Theoretical framework and conceptual model

Social networks in the medical community

Some of the contradictory results for network effects in the literature may be attributable to differing study contexts, different relationships, and different operationalizations of network measurements[8]. Contextualization (i.e., where a study's context is described) of network studies makes theoretical models more accurate and interpretation of empirical results more robust[9]. We therefore start with describing the study's background, the innovation studied and why we expect network effects to be important for the adoption of this innovation.

In many countries like the USA, Canada, Australia, and in several countries in Europe, competency-based education has been introduced into postgraduate medical education. In the Netherlands, competency-based education was introduced in 2004 by the Royal Dutch Medical Association (RMDA), a national board responsible for legislation on postgraduate medical specialist training[10]. Our study specifically focuses on one key innovation introduced to support competency-based education: the so-called "structured competency-based feedback".

Before 2004, feedback in postgraduate medical specialist training programs, if offered at all, was given in an unstructured and sometimes derogatory manner. To improve this feedback process, the RMDA developed the structured competency-based feedback procedure. This innovation needed to be adopted by medical specialists in teams that train residents. Therefore, the use of this innovation was mandated by the RMDA, and considerable effort was invested by this organization in promoting its use.

The RMDA sent all information about the innovation to the program director, the medical specialist responsible for the training of residents in a particular team, and responsible for diffusing this information to the other medical specialists within the team. To facilitate adoption, the RMDA thus relied heavily on the peer-to-peer network effects between the clinical leader (i.e., the program director) and his/her followers (the medical specialists in the team that train residents). Therefore, we have well-grounded reasons to expect these network effects to be important in the adoption of the innovation structured competency-based feedback.

A second reason to expect considerable network effects is that in organizations that emphasize professional egalitarianism, such as in the medical community, the formal leader's power sources are mostly restricted to relational power bases[11]. Leaders occupying central network positions are viewed as potentially powerful because of their greater access to and possibilities for controlling relevant resources[12]. The relational power to control relevant resources engendered by being central in the social network is then likely to complement the clinical leader's formal power.

Leader centrality indices

Many centrality indices have been developed over the years. Looking at past research, the ones that are most often studied are degree centrality, betweenness centrality, and, to a lesser extent, closeness centrality and eigenvector centrality (see Figure 1 for descriptions of these four centralities). We chose these indices because they represent distinctly different ways of being central in the network, which also might influence the leader's ability to enhance innovation adoption of followers. Moreover, with these indices we have a good mix between 1) well-researched indices (such as degree centrality) in order to directly compare our results to previous research in which these centralities were studied in isolation, and 2) fairly new, but highly promising indices (such as eigenvector centrality), making it possible to extend the current leader centrality research using state-of-the-art indices.

In the next subsections, we will build our hypotheses concerning the effectiveness of clinical leaders in terms of innovation adoption which results from occupying central positions, using the four different centrality indices. Figure 2 provides a summary of our hypotheses (conceptual model).

Clinical leader degree centrality: Popular leaders

Leaders with high degree centralities have a large degree of direct contact with their team members, and are often called *popular leaders* (see Figure 1), because they are the most visible actors in the network[5]. These leaders have the potential for activity in communication, and signify who is "in the thick of things"[6]. We expect positive effects on followers' innovation adoption of these popular clinical leaders. The high degree clinical leaders are in the position to be highly visible and to be active, which provides them with the opportunity to expose their ideas on innovations towards their

Figure 2
Summary of hypotheses

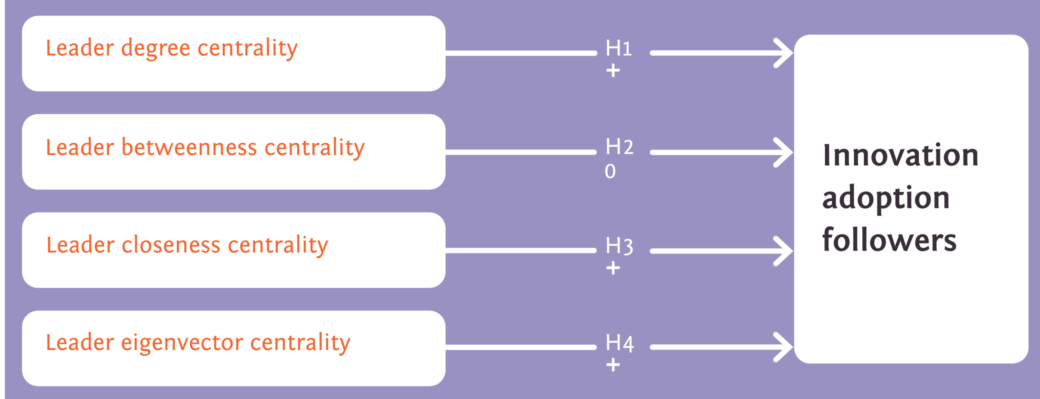
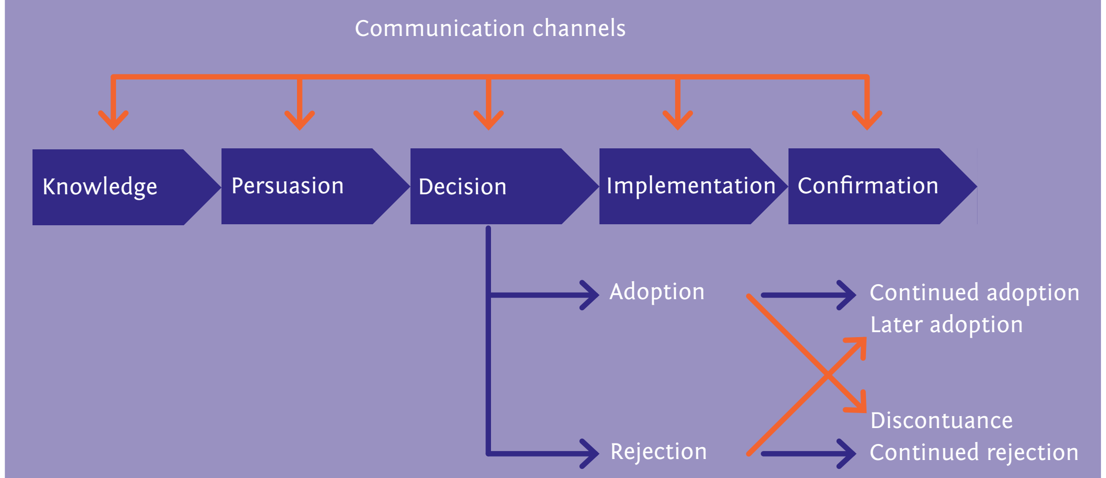


Figure 3
Innovation-decision process (adapted from Rogers, 2003)



followers. Due to their high visibility they are able to make full use of the "diffusion capacities" of the team's social network. The team's social network diffuses information naturally by functioning as 1) channels for communication, 2) social construction, and 3) negotiation of the innovation. This increases the observability of the innovation; and, therefore, reducing the perceived risk by eliminating novelty or uncertainty for potential adopters of the innovation[4,13].

The second reason why we believe that high degree centrality clinical leaders will positively influence their followers' adoption is based upon insights from both social learning theory[14,15], as well as diffusion theory[4]. First of all, the central premise behind social learning theory is that an individual learns from others by means of observational modeling: The adopter observes others' behavior and acts similarly. This is not to be confused with simple imitation; in social modeling, the adopter extracts the essential elements from an observed behavioral pattern in order to perform in a similar fashion.

Related to social learning theory, is diffusion theory. Both theories share basic premises, since both theories seek to explain how individuals change behavior as a result of (verbal and non-verbal) communication with others. Diffusion can be defined as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p. 5). Diffusion concerns a two-way process of communication convergence dealing with new ideas. According to Rogers (2003, p. 103) "the diffusion theory/model is a conceptual paradigm with relevance for many disciplines…it provides a common conceptual ground that bridges these diverse disciplines and methodologies." Note that both theories consider information exchange as essential to behavioral change, and stress social network connections as the main predictors[4,14,15]. These observational modeling effects could be strong for high degree centrality clinical leaders, because their visibility provides their followers with high exposure to model the desired behavior.

Our reasoning is supported by evidence of leader and actor degree centrality studies on performance. An empirical study among 364 teachers in 17 elementary schools showed that higher-performance schools had principals (heads of school) with high degree centralities (in their advice network)[11]. The authors suggested two explanations:

Accessibility and attentiveness to matters of concern to teachers, and collaborative problem-solving and decision-making in a context of mutual respect. These arguments may also apply to our study in which we focus on innovation adoption instead of performance. The high degree clinical leaders provide their medical specialists followers with accessibility to discuss the pros and cons of the innovation competency-based structured feedback. This could especially apply to adoption, since adoption is a two-way process of communication between the person planning to adopt and the person that has already adopted[4]. Moreover, because medical specialists are used to discuss medical issues in their regular day-to-day work (diagnosis and treatment of patients), we expect the same behavior in adopting a new structured feedback routine.

To summarize, we expect clinical leaders with high degree centralities to make full use of the diffusion capacities of the social network, to provide exposure to their followers which allows observational modeling and to be accessible to their followers to discuss the benefits of the innovation. Therefore we hypothesize that:

Hypothesis 1: *The higher the clinical leader degree centrality, the higher the innovation adoption of team members.*

Clinical leader betweenness centrality: Brokerage leaders

Leaders with high betweenness centralities have a high degree of indirect contacts with their team members. This centrality index represents the ratio of the number of times a leader is on the geodesics (shortest path between two team members) of their team members to the maximum amount possible[5]. These leaders are literally on the shortest paths between their team members (see Figure 1) and have the potential to control information and coordinate group processes, and therefore are also called *brokerage leaders*[6]. We expect neutral or no effects on followers' innovation adoption of clinical leaders occupying central positions according to betweenness centrality. We will explain this by looking more closely at the innovation decision process (Rogers, 2003), as illustrated in Figure 3.

As shown in the figure, in order for someone to adopt, one needs to receive knowledge about the innovation (stage 1) and to feel some persuasion to consider adoption (stage 2). After this consideration, one decides either to adopt or not to adopt (stage 3) and in the case of the former, the adopter needs to implement (stage 4) and confirm the adoption behavior (stage 5) to reach full and consistent adoption. We propose that the capacities of leaders with high betweenness centralities may be particularly useful in the first two stages (knowledge and persuasion). However, they may fail in reaching full adoption among their followers in the subsequent stages (decision, implementation and confirmation). We will turn to related work on leader- and actor betweenness centrality and performance to explain our reasoning.

Information is commonly dispersed across a team, and the brokerage leader can tap those diverse information pools. By acting as a bridge between two otherwise unconnected team members or subgroups, the brokerage leader is in a position to utilize differences between the unconnected parties for their own benefit[16]. By acting as brokers, formal team leaders can help integrate specialists, avoid redundant use of resources, and put people in touch with each other[16,17]. Brass (1984) showed that individuals with high betweenness centrality in the communications network have significantly higher chances of being promoted[12]. This might be attributed to their unique abilities in leveraging disperse information to their own benefit. Betweenness centrality independently predicted individuals' workplace performance[18]. Finally, a meta-analysis of eight studies found that individuals with high betweenness centralities are likely to emerge as leaders, to be more satisfied, and to participate more in the task solution[6].

These empirical studies show that individuals and leaders occupying central positions according to betweenness centrality are highly effective in spotting new ideas and retrieving and controlling information. These capacities are very useful in the first two stages of the innovation decision process; knowledge and persuasion. However, for followers to actually adopt a particular innovation proposed by their leader, the leader needs to have a certain exposure to their followers. This exposure provides the opportunity for followers to discuss the benefits of the innovation with the leader and to allow for observational modeling of the desired behavior. High betweenness centrality leaders are not embedded in the social network with their followers to provide the necessary exposure. They primarily have indirect ties with their followers, and not the direct ties that offer these exposure opportunities.

We believe that this reasoning in particular applies to the leaders studied in our sample; the program directors. Their work is fragmented because they have to divide their time between providing patient care, doing research and providing (and leading) postgraduate medical specialist training. In many cases, the program director is not only head of the medical specialist training, but also the head of patient care or even of the entire department. This fragmentation combined with the high workload of the leader and of the followers, means that there is very little time to discuss innovations between the clinical leaders and their followers; the other medical specialists in the team. For example, a complaint very often heard is that clinical leaders are always unavailable because they are away at conferences abroad or meetings outside the hospital[19]. In other words, clinical leaders are, due to the circumstances of their work, limited in their abilities to provide enough exposure to their followers in discussing innovations and showing the desired behaviors. Clinical leaders high in betweenness centrality could reinforce these effects; their few direct ties due their position in the social network combined with the constraints imposed by the nature of their work, leads to marginal exposure to their followers of the desired adoption behavior.

Therefore we hypothesize that:

Hypothesis 2: *Betweenness centrality of clinical leaders will have no effect on the innovation adoption of followers.*

Clinical leader closeness centrality: Efficient leaders

Closeness centrality refers to persons who can quickly interact with all others and have a broad “reach” across the network (see Figure 1). Leader closeness centrality is computed as the inverse of the sum of the distances from the leader to all team members. As distances decrease, the centrality index increases[5]. Leaders with high closeness centrality represent the potential for independence and efficiency; these persons can avoid influence from others and spread the message to others in a minimal amount of time[6]. We define these persons as *efficient leaders*. We expect strong positive effects of clinical leaders occupying high closeness centrality positions on their followers’ innovation adoption. We expect that high closeness centrality leaders can benefit of both high degree centrality leaders (their high visibility) and betweenness centrality leaders (their abilities to control information). This reasoning is based on related research on leader closeness centrality and performance outcomes.

In their empirical study on 250 MBA students, Baldwin et al. (1997) showed that students’ centrality, as defined by Stephenson and Zelen (an index quite similar to closeness centrality), was positively linked to individual grades. The authors suggested that students high in centrality were better able to avail themselves of resources and support than were students with lower centralities. Feeley (2000) found that employees (n = 70 from three organizations) with high closeness centralities tended to remain in their positions (lower employee turnover). Furthermore, he found that degree and betweenness centrality were unrelated to employee commitment, while closeness centrality was positively related to this variable. This result was interpreted as those employees closer to others have more direct access to others and have more friendships, which serve as a buffer against the stress of everyday work. Another explanation is that those employees have more critical information regarding their job which could facilitate job duties[20].

Most importantly and closely related to the current study, Jippes et al (2010) showed that 81 medical specialists with high closeness centralities were more likely to show adoptive behavior. Closeness centrality was a stronger predictor of adoptive behavior than following an intensive course aimed at implementing the particular innovation. The authors looked at the network position of medical specialists, while the current study looks into the network position of clinical leaders.

A central finding in these studies is that individuals high in closeness centrality were able to find critical information, and avail themselves of valuable resources. We believe that there are two paths, direct and indirect, for people to be able to find this information and resources. Direct ties between the leader and the follower are useful to tap the diffusion capacities of the social network, to provide exposure from the leader to the followers which allows observational modeling and for the leader to be accessible to his or her followers to discuss the benefits of the innovation. For spotting new ideas and retrieving and controlling information, indirect ties between the leader and his or her followers are necessary.

The high closeness centrality leader has both direct and indirect ties capacities. We therefore expect a positive effect. Moreover, we believe these positive effects to be particularly strong in the sample we used. The medical community is characterized by strong professional egalitarianism, which means that the formal leader's power sources are mostly restricted to relational power (embedded in the leader's ties with followers) and expert power[11]. The clinical leader with high closeness centrality is expected to have enough visibility to stimulate follower medical specialist adoption, while he or she is also able to spot new ideas, knowledge and innovations and thus be considered an expert. Therefore we hypothesize that:

Hypothesis 3: *The higher the clinical leader closeness centrality, the higher the innovation adoption of team members.*

Clinical leader eigenvector centrality: Borrowed glory leaders

Instead of degree centrality, which weighs every contact equally, the eigenvector centrality weighs contacts according to their degree centralities (see Figure 1). The eigenvector centrality will be high for persons with low degree centralities who are connected to persons with high degree centralities, and vice versa[21]. These leaders are also referred to as *borrowed glory leaders*, since a low degree centrality borrows glory from a high degree-centrality individual[22]. In our study, the clinical leader with high eigenvector centrality is connected to high degree follower medical specialists. These high degree followers are highly visible and active, enabling the clinical leader to the benefits of having direct ties as stated in the previous sections. Moreover, leaders high in eigenvector centrality could avoid the perils of leaders with high degree centrality (too many ties to maintain) and high betweenness centrality (conflicting demands from disconnected others). We therefore expect positive effects of clinical leaders high in eigenvector centrality on innovation adoption of their followers. To support our reasoning, we will turn again to the literature on the effect of leader eigenvector centrality on performance.

In a financial corporation, Mehra, Dixon, Brass and Robertson (2006) found that leader eigenvector centrality (n = 81) in the friendship network inside their own groups was positively related to customer loyalty and leadership reputation. Friendship ties of group leaders play a dual role: They provide leaders access to resources that facilitate group performance and they also help them secure favorable leadership reputations[23]. In an advertising and public relations agency (n = 80), Ibarra (1993) found that centrality – as measured by eigenvector centrality in a "combined" network of communication, advice, support, influence, and friendship – was the most significant

predictor for innovation involvement in administrative innovations (changes in structure and processes). Note that in this study eigenvector centrality was not related to technical innovations (changes in primary work activity). One explanation might be that administrative innovations require a greater degree of cross-unit interaction than technical innovations in order to mobilize resources; therefore, centrality is of greater importance for leveraging the former innovation type[24].

We believe that some of the arguments in these studies may apply to innovation adoption in our sample studied. First, leaders high in eigenvector centrality may have easy access to critical information and valuable resources because they are connected to influential followers. This is important for the first stages of the innovation decision process; knowledge and persuasion. Second, high eigenvector centrality leaders may acquire favorable leadership reputations through their connections with influential followers. This applies particularly well to our sample studies, because medical specialists are very receptive to influential credible colleagues[11]. Especially younger clinical leaders could be undermined by older colleagues; in particular ones that formerly headed the team. To a large extent, these youngsters are dependent on their network connections with credible older colleagues in order to influence other medical specialists in the team. A clinical leader connected to credible colleagues may attain also a more favorable leadership reputation, which provides opportunities to influence team members to adopt the desired innovation. Therefore, we hypothesize that:

Hypothesis 4: *The higher the clinical leader eigenvector centrality, the higher the innovation adoption of team members.*

Methods

Research context

As explained in the introduction, we used data on innovations in Dutch postgraduate medical specialist training programs. There are 27 postgraduate training programs, in medical (e.g., internal medicine, pediatrics, neurology, dermatology), surgical (e.g., surgery, orthopedic surgery, gynecology, ear-nose-and-throat surgery), supportive (e.g., anesthesiology, emergency medicine) and diagnostic (e.g., radiology, microbiology, nuclear medicine) disciplines in the Netherlands. The training programs take place in a total of around 70 teaching hospitals (both university and general teaching hospitals). In 2004, the

Royal Dutch Medical Association (RDMA) introduced competency-based education in postgraduate training throughout the Netherlands[10]. In competency-based education, medical specialists are trained according to a set of seven core competencies: medical expert, collaborator, communicator, professional, health advocate, management, and scholar[25]. Among all of the innovations introduced by the Royal Dutch Medical Association, the structured competency-based feedback was considered to be the key innovation by most specialists. When feedback takes place in a safe, timely, specific, and well-structured way, this assessment can be a valuable supervision and learning mechanism[26].

Historically, postgraduate training in the Netherlands was characterized mainly by "learning on the job," and neither the method nor the frequency of feedback was structured. Evaluation of the progress of residents (medical specialists in training) was, therefore, rather informal. In a recent pilot project related to the implementation of new postgraduate medical specialist training programs, both residents and medical specialists indicated that the introduction of such structured and constructive feedback was the most important innovation in the renewed curricula[19].

We use the implementation of the new feedback procedure as a proxy of innovation. Whether or not an idea, concept, method, product, or service is considered an innovation is dependent on the newness for the adopting organization[27]. In other words, something can be new and innovative for one organization, whereas other organizations have already adopted it. The structured feedback technique was new and highly innovative for the medical community in the hospitals. For the medical specialists, this (educational) innovation consisted of a considerable shift from existing practice.

To sum up, the structured feedback technique was to be adopted by all (about 200) medical specialist teams training residents. We treat the program directors as the formally appointed clinical (team) leaders, and measure their centrality indices. We assess the effect of these clinical leader centrality indices on the adoption of the structured feedback technique by the clinical leader's followers (the medical specialists).

Sample

Data were gathered between 2007 and 2010 from 24 radiology teams, 4 obstetrics & gynecology (O&G) teams, 5 pediatric teams, and 5 anesthesiology teams in the Netherlands. The total number of teams and thus also of clinical leaders was 38, each team has one clinical leader (the program director). The total sample included 613 medical specialists, these are the followers (370 radiologists, 50 gynecologists, 46 pediatricians, and 147 anesthesiologists), and 571 residents (344 in radiology, 50 in O&G, 36 in pediatrics, and 141 in anesthesiology) spread across the 38 teams. The teams varied in size between 8 specialists and 50 specialists. We had teams consisting of a surgical discipline (O&G), a non-surgical discipline (pediatrics), a diagnostic discipline (radiology), and a supporting discipline (anesthesiology). From the total sample of 613 medical specialists, 420 responded to the questionnaire (69%). After discarding questionnaires with incomplete answers, a total of 370 (60%) were analyzed. From the total sample of 571 residents, questionnaires from 357 respondents (63%) were included.

Questionnaire

The medical specialists and residents received a structured and validated questionnaire[28]. For the medical specialists, the questionnaire included questions about the independent variables and control variables. The questionnaire for the residents included questions about the dependent variable (structured feedback by the followers; the medical specialists).

Dependent variable

Follower innovation adoption

The dependent variable in this study consists of the adoption by medical specialists of the innovative "structured feedback". This is based on "Pendleton's rules": (1) the feedback is structured, (2) the medical specialist gives the resident the opportunity to give his/her opinion, (3) the medical specialist provides positive points, (4) the medical specialist provides specific points for improvement, and (5) the medical specialist provides the feedback in a "safe" way[29]. Every medical specialist in our sample was rated by at least two residents on these points on a five-point Likert scale ranging from "totally disagree" to "totally agree", including "not possible to assess this medical specialist". The arithmetic average of the residents' answers for each supervising medical specialist on all five points was used as the coefficient for individual innovation adoption of structured feedback by the medical specialists.

Independent variables

Social network data preparation

Kratzer, Leenders and Van Engelen (2008) summarized different types of networks (or contents of the networks): workflow networks (exchange of goods or services), information exchange networks (exchange of information, knowledge, advice, and problem-solving communication), and non-work-related networks (exchange of affect and friendships). Information exchange networks were found to be a conduit for innovation diffusion and adoption[4,5]. This type of network has also been studied in relation to leader centrality (e.g. Kratzer et al., 2008). Therefore, we focused on information exchange networks and, more specifically, on the "communication innovation network".

We used a full roster design. Each medical specialist received a list with all names of their fellow medical specialists in their department, and was asked to rate their communication intensity with each of their fellow medical specialists in their own teams. In the questionnaire, communication was specified as "communication in the past half year about the introduction of innovations, new methods or procedures, or new developments related to the work situation". The rating was scored on a six-point scale from "never", to "less than once a month", "more than once a month", "weekly," "daily", or "more than once daily" (also used by[30]). We used UCINET VI[31] to analyze the data.

The answers given by the respondents produced a directed valued matrix. In order to compute the centrality indices, the data needed to be transformed into an undirected dichotomous (symmetric) matrix. The maximum symmetrizing method was used to convert the directed matrix into an undirected one and to correct for missing network data. In this method, the highest rating of communication intensity between two persons was used, or, in the case of missing network data, the rating from one person. To dichotomize the valued matrix (ranging from 1 to 6), we recoded the values one and two into zero (no communication), and the values three, four, five, and six into one (communication relationship). After preparation of the social network data, we computed the four centrality indices.

Clinical leader degree centrality

Degree centrality refers to persons who are most visible in the network, i.e., those with a large degree of direct contact or are adjacent to many other persons[5]. We calculated (see Appendix 1, equation 1.1) the standardized degree centrality for every clinical leader and used it to test Hypothesis 1.

Clinical leader betweenness centrality

Betweenness centrality refers to individuals who are on the communication paths between two other actors[5]. This index represents the ratio of the number of times an actor is on the geodesics (shortest path between two actors) of other actors to the maximum amount possible. We calculated (see Appendix 1, equation 1.2) this centrality measurement for every clinical leader in order to test Hypothesis 2.

Clinical leader closeness centrality

Closeness centrality refers to persons who can quickly interact with all others; these actors can be very productive in communicating information to others in the network[5]. The index is the inverse of the sum of the distances from actor *i* to all other actors. As distances decrease, the centrality index increases. We standardized this index and computed it (see Appendix 1, equation 1.3) for every clinical leader to test Hypothesis 3.

Clinical leader eigenvector centrality

Instead of degree centrality, which weights every contact equally, the eigenvector weights contact according to its degree centrality. The eigenvector centrality will be high for persons with low degree centralities who are connected to persons with high degree centralities, and vice versa[21]. We standardized this index and computed it (see Appendix 1, equation 1.4) for every clinical leader in order to test Hypothesis 4.

Control variables

We controlled for the effect of gender, age, attitude, length of employment, and hours of employment of both the team members (followers) and the clinical leaders (all specified below). Social networks among men and women differ in complex ways, particularly in relation to life stage. Older people tend to have larger and older networks which are less geographically proximal[32]. In healthcare, attitude and motivation seem to be important for innovation adoption as well[33]. Medical specialists rated the question, "Structured feedback is an improvement in the quality of postgraduate medical specialist training," on a five-point Likert scale ranging from "totally disagree" to "totally agree." Finally, research shows that the longer a person worked in an organization, the more negative the scoring on job satisfaction, the effect of budget adjustments on individual job-related stress, the quality of individual performance, and department morale[34]. No significant differences between part-time and full-time "inventors" were found in earlier research[35], but since an increasing number of healthcare professionals have part-time appointments, this variable was included.

Data analysis

First, we conducted a reliability and factor analysis to look into the validity of our dependent variable. Although the four centrality indices have different conceptual meanings, they all measure centrality; therefore, we conducted a correlation analysis to see how the indices were correlated. To account for the nested structure (individuals within teams) of the data, we conducted a two-level hierarchical linear model (Level 1 for the individual and Level 2 for the teams). Applying hierarchical linear modeling permits testing influence of team-level variables on individual-level variables without biasing the standard error estimates. This advantage is particularly important when team-level variables – in our case clinical leader centrality – are hypothesized so as to influence individual-level variables, in our case follower innovation adoption[36].

The team member and clinical leader control variables were entered into the model first. We entered the centrality indices separately into the model in order to assess the contribution of each leader centrality index. The individual control variables were inserted on the individual level (Level 1) and the other variables (clinical leader control variables and clinical leader independent variables) on the team level (Level 2). Finally, all leader centralities were entered together in one model to test whether they have differential and unique effects.

The control variables, age (minus 30 percentage points), attitude (minus 1 percentage points), and hours of employment (minus 15 percentage points), were centered before they were entered into the model. These variables were skewed, and centering improves model interpretation[37]. To test whether innovation adoption could be attributed to the type of specialism (O&G, pediatrics, radiology, anesthesiology), we entered this as a categorical variable into all models. Nowhere was type of discipline significantly related to our dependent variable; therefore, pooling data across the disciplines was justified. Finally, to avoid misinterpretation, we tested for possible curvilinear relationships between the clinical leader centrality indices and innovation adoption (as found by[30]).

Results

Reliability and factor analysis

Reliability analysis yielded a Cronbach's alpha of .85 for the five questions that measured the dependent variable "structured feedback." Factor analysis revealed one construct under these questions (eigenvalue of 3.147 and 63% explanation of variance). The assumptions for factor analysis were met. There was no multicollinearity; the Kaiser-Meyer-Olkin measurement was .797 and Barletts' test was significant ($p < .01$). In Table 1 and 2 the descriptive statistics and correlation analyses for the individual variables (Table 1) and the team-level variables (Table 2) are presented.

Correlation analysis

As expected, the four centrality indices were shown to be significantly correlated. Leader degree and closeness centrality showed especially high correlations ($r = .85$, $p < .01$), which may be attributed to the fact that they both measure the connectedness through direct ties; the difference is that closeness centrality also measures indirect ties.

Hierarchical linear model

Table 3 shows the results for the regression analysis. The null model showed the most variance on the individual level, followed by the team level. The attitude of team members ($p < .05$) showed a significantly positive relationship to innovation adoption, but none of the other control variables showed a significant effect in Model 1.

In Model 2 we entered clinical leader degree centrality to test Hypothesis 1, which showed a significantly positive relationship ($p < .01$). Leader gender ($p < .01$) (male = reference category), leader hours of employment ($p < .05$) and the attitude of team members ($p < .05$) also showed a significantly positive relationship. Model 2 explained 10.74% of the variance in follower innovation adoption. These findings led us to accept Hypothesis 1.

Table 1

Descriptive statistics and correlations for individual-level variables

	N	Scale used	Min.	Max.	Mean	SE	1	2	3	4	5
Dependent variable											
1. Follower innovation adoption	370†	1-5	1.90	5.00	4.06	.47					
Individual team members control variables											
2. Gender	370†						-.02				
Males	261										
Females	109										
3. Age	370†	Years	30.00	65.00	46.75	8.39	*-.14***	*-.21***			
4. Attitude	370†	1-5	1.00	5.00	4.27	.85	*.07*	*.10*	*-.01*		
5. Hours of employment (part-time/full-time)	370†	%	15.00	100.00	92.00	14.37	*.10*	*-.31***	*-.09*	*-.06*	
6. Length of employment	370†	Years	.00	35.00	10.45	8.33	*-.10*	*-.22***	*.78***	*.05*	*.01*

† This variable is on the individual level (Level 1); this N therefore represents the number of team members (medical specialists)

* $p < .05$

** $p < .01$

Table 2

Descriptive statistics and correlations for team-level variables

	N	Scale used	Min.	Max.	Mean	SE	1	2	3	4	5	6	7	8
Clinical leader control variables														
1. Gender	38†													
Male leaders	35													
Female leaders	3													
2. Age	38†	Years	36.00	61.00	48.47	6.35	*-.11*							
3. Attitude	38†	1-5	1.00	5.00	4.30	.98	*-.01*	*-.02*						
4. Hours of employment (part-time/full-time)	38†	%	70.00	100.00	96.43	8.10	*-.34**	*.28*	*.11*					
5. Length of employment	38†	Years	1.00	25.00	11.39	6.72	*-.08*	*.75***	*.08*	*.07*				
Clinical leader independent variables														
6. Clinical leader degree centrality	38†	0-100	8.33	100.00	48.56	30.75	*-.15*	*.17*	*.08*	*.21*	*-.01*			
7. Clinical leader betweenness centrality	38†	0-100	0.00	100.00	10.32	18.39	*-.14*	*-.13*	*.22*	*-.01*	*-.10*	*.46***		
8. Clinical leader closeness centrality	38†	0-100	9.36	100.00	55.59	29.56	*-.10*	*.13*	*-.05*	*.21*	*.06*	*.85***	*.32**	
9. Clinical leader eigenvector centrality	38†	0-100	18.36	92.31	48.62	16.02	*-.02*	*-.10*	*-.07*	*-.07*	*-.26*	*.61***	*.61***	*.31*

† This variable is on the team level (Level 2); this N therefore represents the number of team leaders and the number of teams

* $p < .05$

** $p < .01$

Table 3

Hierarchical linear model for follower innovation adoption

	Model 0	Model 1 Control variables	Model 2 Hypothesis 1	Model 3 Hypothesis 2	Model 4 Hypothesis 3	Model 5 Hypothesis 4	Model 6 All centralities
Constant	4.098 (.065)	3.358 (.488)	2.316 (.557)	3.457 (.506)	2.088 (.558)	3.989 (.055)	2.230 (.604)
Individual control variables							
Gender (male is reference category)		-.005 (.056)	.016 (.055)	-.003 (.056)	.023 (.054)	-.003 (.056)	.027 (.054)
Age		-.007 (.004)	-.007 (.004)	-.007 (.004)	-.008 (.004)*	-.006 (.004)	-.008 (.004)*
Attitude		.047 (.028)*	.048 (.027)*	.047 (.028)*	.043 (.027)	.048 (.028)*	.043 (.027)
Hours of employment		.003 (.002)	.003 (.002)	.003 (.002)	.002 (.002)	.003 (.002)	.002 (.002)
Length of employment		-.001 (.004)	-.002 (.004)	-.001 (.004)	-.001 (.004)	-.002 (.004)	-.001 (.004)
Clinical leader control variables							
Leader gender (male is reference category)		.111 (.139)	.427 (.160)**	.091 (.139)	.565 (.167)**	.115 (.138)	.587 (.174)**
Leader age		<.000 (.008)	<.000 (.008)	<.000 (.008)	-.003 (.008)	<.000 (.008)	.002 (.008)
Leader attitude		-.001 (.026)	.012 (.026)	.003 (.027)	.022 (.026)	-.010 (.028)	.034 (.030)
Leader hours of employment		.004 (.006)	.015 (.006)*	.003 (.006)	.018 (.006)**	.007 (.006)	.017 (.007)**
Leader length of employment		.008 (.007)	.003 (.008)	.008 (.007)	<.000 (.001)	.008 (.007)	-<.000 (.008)
Independent clinical leader centrality variables							
Leader degree centrality			.004 (.001)**				.002 (.003)
Leader betweenness centrality				-.001 (.002)			-.001 (.002)
Leader closeness centrality					.005 (.001)**		.004 (.002)*
Leader eigenvector centrality						.002 (.002)	-.002 (.004)
Variance							
Level 1 individual	.197 (.001)	.186 (.014)	.176 (.013)	.186 (.014)	.172 (.013)	.186 (.014)	.171 (.013)
Level 2 team	.045 (.022)	.053 (.025)	.123 (.005)	.050 (.024)	.164 (.067)	.051 (.025)	.051 (.025)
Explained variance							
Level 1 individual		5.54%	10.74%	5.48%	12.86%	5.75%	13.16%
Level 2 team		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
-2 Log likelihood	471.021	452.319	442.499	451.987	437.855	451.224	436.820

* $p < .05$

** $p < .01$

In Model 3 we assessed clinical leader betweenness centrality as having no significantly relationship to follower innovation adoption (Hypothesis 2). Only the attitude of team members ($p < .05$) showed a significantly positive relationship to follower innovation adoption in this model. In line with Hypothesis 2, we did not find an effect for clinical leader betweenness centrality.

In Model 4 we entered clinical leader closeness centrality to test Hypothesis 3. This significantly improved the model's fit (12.86% explained variance). Clinical leader closeness centrality had a significantly positive relationship ($p < .01$) with follower innovation adoption. Like Model 2, Model 4 shows significantly positive relationships for leader gender ($p < .01$), leader hours of employment ($p < .01$), and attitude of team members ($p < .05$) with follower innovation adoption. The findings on clinical leader closeness centrality led us to accept Hypotheses 3.

Clinical leader eigenvector centrality was entered in Model 5. Clinical leader eigenvector centrality showed no significant relationship with follower innovation adoption, which led us to reject Hypothesis 4. Only the attitude of team members ($p < .05$) showed a significantly positive relationship to follower innovation adoption.

Finally, we entered all centralities in model 6. Only clinical leader closeness centrality had a significantly positive relationship ($p < .05$) with follower innovation adoption. Like Model 2 and 4, Model 6 shows significantly positive relationships for leader gender ($p < .01$), leader hours of employment ($p <.01$), and attitude of team members ($p < .05$) with follower innovation adoption. Model 6 explained 13.16% of the variance in follower innovation adoption.

The analyses for possible curvilinear relationships between the clinical leader centrality indices and follower innovation adoption revealed a small but significantly negative curvilinear (indicating an inverse U-shaped) relationship between clinical leader eigenvector centrality and innovation adoption (β = -.00026 (.00011), $p < .05$). The other clinical leader centrality indices showed no curvilinear relationships.

Discussion

This study compared the contributions of clinical leader centrality (as measured by four different centralities) to the adoption of an innovation (a novel structured feedback format to evaluate residents in training) by 370 medical specialists in 38 teams. We found support for 3 (out of 4) of our hypotheses. Clinical leader degree centrality and clinical leader closeness centrality had significantly positive relationships and clinical leader betweenness centrality no significantly relationship with follower innovation adoption. In a complete model, only clinical leader closeness centrality remained a significant predictor of innovation adoption. Lastly, clinical leader gender (female leaders), leader hours of employment, and follower attitude were positively related to follower innovation adoption. Based on these findings, we accepted Hypotheses 1, 2 and 3 (positive effect from clinical leader degree and closeness centrality, no/neutral effect for clinical leader betweenness centrality).

Our findings are an important extension of previous research on leadership and innovation adoption. Previous research in healthcare showed the importance of degree and closeness centrality of the medical specialists (in our study termed as followers) on their innovation adoption[28]. The current study shows the importance of these centrality indices for the position of the clinical leader as well.

Clinical leader centrality

When we look in more detail to our results on the influence of clinical leader centrality, there are several interesting remarks to make. First of all, we found only two centrality indices to be significant (degree and closeness), and two other indices not to be significant (betweenness and eigenvector). Note that degree centrality measures connectedness in terms of direct ties, and closeness centrality in terms of both direct and indirect ties. This similarity was also expressed in the high correlation between degree and closeness centrality. Betweenness and eigenvector centrality, however, illustrate the connectedness through indirect ties. Our results therefore indicate that, regarding follower innovation adoption the direct ties between clinical leaders and their followers are more important than (only) indirect ties.

These results can be explained by social learning theory and diffusion theory. Both theories emphasize the importance of visibility and exposure of the primary adopters in order for followers to observe, exchange information, capture the essence, and apply the innovation themselves. Direct ties through degree and closeness centrality may provide the clinical leader with the visibility and exposure to use the diffusion capacities of the team's social network. A second explanation might be that the visibility and exposure of high degree and high closeness clinical leaders provide their medical specialists (i.e., followers) with more opportunities to discuss the benefits of the innovation. Given that medical specialists are used to discuss medical issues in their regular day-to-day operations, we could expect the same behavior in adopting innovations. That is, innovation adoption concerns a two-way process of communication, rather than a one-way, linear act in which one individual seeks to transfer a message to another[4].

Second, we indeed found no effect of clinical leader betweenness centrality. Although one should be careful interpreting null-effects, one explanation might be that this index measures the connections through indirect ties. Perhaps the connectedness of leaders in terms of indirect ties to their followers is important for knowledge penetration and persuasion of potential adopters; both early stages of the innovation-decision process model (see Figure 3). However, as argued before, for followers to decide to adopt a particular innovation proposed by their leader, the leader needs to have a certain exposure to their followers. This exposure provides the opportunity for followers to discuss the benefits of the innovation with the leader and to allow for observational modeling of the desired behavior. High betweenness centrality leaders have primarily indirect ties with their followers, and not the direct ties that offer these exposure opportunities. These inherent deficits of leaders high in betweenness centrality may have been reinforced by the constraints imposed by the nature of the work of the clinical leaders (the program directors) in our study; this work is highly fragmented with very little time to discuss innovations.

A third interesting and unexpected finding was that we did not find the hypothesized effects of clinical leader eigenvector centrality. However, an extra test for curvilinear relationships revealed a negative curvilinear (indicating an inverse U-shaped) relationship for clinical leader eigenvector centrality on innovation adoption. This indicates that clinical leaders should be moderately connected to significant followers. None of the other clinical leader centrality indices showed this kind of relationship. A possible explanation for this could be that the position and the credibility of the clinical leader may be undermined if he or she is relying too much on the credibility of his or her high degree followers. To some degree relying on these high degree followers is beneficial, enabling the clinical leader to benefit from the high activity and exposure competences of these high degree centrality followers. Too weak (i.e. that means leaders with low eigenvector centralities) may be detrimental to the leader's visibility for and influence on these subordinates, while too high (i.e. that means high eigenvector centralities) may lead to a loss of credibility and importance of the clinical leader's own position. Within the medical community this might especially be true, as, due to professional egalitarianism, the medical specialists are very receptive to influential and credible colleagues. In sum, our findings suggest that eigenvector centrality is somewhat different in its effect on innovation adoption then initially hypothesized. Our findings indicate that *to some extent* clinical leaders can benefit of being highly embedded in their social network according to eigenvector centrality.

Finally, our results showed clinical leader closeness centrality to be the strongest predictor of followers' innovation adoption as it remained significant, even after controlling for the effects of the other centrality indices. This effect of clinical leader closeness centrality could be explained by the strong professional egalitarianism culture in the medical community. The clinical leader with high closeness centrality has enough visibility to stimulate follower medical specialist adoption, while he or she is also able to spot new ideas, innovations, knowledge and thus to be considered an expert.

Individual and clinical leader control variables

When we look at the individual variables and the control variables, we see that medical specialists with a more positive attitude towards the innovation were more likely to properly apply it. This is in line with previous research, and suggests that also in healthcare positive motivation and attitude are important factors for the adoption of innovations[33].

Moreover, we found several of the clinical leader control variables to be significantly related to follower innovation adoption. Female leaders managed teams to obtain higher innovation adoption. This outcome may have been the result of the low proportion of female leaders in our sample. The fact that there were few female leaders might have resulted in a high intrinsic motivation to set an example and perform at a high level. Note that the small number of female leaders in our sample (n = 3) itself calls for caution in interpreting these particular results. Future research could focus on the influence of leader gender on innovation adoption.

Finally, medical specialists working with clinical leaders who worked more hours (per week) were more likely to adopt the innovation. One of the explanations could be that these clinical leaders were more visible and more available to team members, which gave followers more opportunities to observe their leader's adoptive behavior and thus feel more compelled to apply the innovation. Again, more research is needed to empirically test this reasoning.

Theoretical and practical implications

Our findings confirmed our argumentation that the effects of leader centrality are dependent on the outcomes studied, i.e., *the context of the study*. Let us explain this by using our results of clinical leader degree centrality. For example, Kratzer et al. (2008) found leader degree centrality (in the workflow network) to be significantly related (inversely U-shaped) to team creativity in a study (n = 321 members in 39 teams) in the space industry. This indicated that leaders should be moderately central: Too strong may lead to information overload on the part of the leader and discourage team members from making decisions; too weak may hamper the leader's ability to monitor communication problems. In the same study it was found that leader degree centrality in the problem-solving network was negatively related to team creativity. Engineering team members may require autonomy in order to find novel and useful solutions[30]. Note that creativity is different from innovation adoption because the former requires a lot of autonomous independent decision-making on the part of the follower. A leader that is too strong in the communication process may discourage members from making these decisions themselves. In innovation adoption this autonomous independent decision-making is less important; the adopter is not required to come up with novel solutions but is only faced with the decision to adopt the innovation. Therefore, we expected and found a positive linear effect of leader degree centrality on innovation adoption. All in all, our results emphasize the importance of describing the context when studying leader centrality.

Our results point to the importance of the so-called *social capital benefits* clinical leaders may yield from holding central network positions. Social capital benefits are gained from the aggregate of resources embedded within, available through, and derived from the network of relationships[38]. For a high level of follower innovation adoption, clinical leaders need to attain high central network positions according to degree and closeness centrality and moderate central network positions according to eigenvector centrality. These positions may provide the direct ties and visibility necessary for follower innovation adoption. To increase their centrality, formal team leaders can take several actions, for example; being more present at team meetings, increasing the frequency of team meetings, and increasing the frequency of bilateral meetings with team members.

Strengths, limitations, and directions for further research

Our study is the first to empirically assess the impact of four different clinical leader centralities on follower innovation adoption in one single dataset. With this study, we extended the understanding of the (structural side of) social capital research in leadership. More specifically, we gave more insights into the leaders' cognition of their wider social networks, and the influence that the actual structure of leaders' ties with their team members has on innovation adoption of their followers. We were able to do so, because we used a dataset with unique features.

This study has a number of strenghts. First of all, our large sample size has made it possible to use hierarchical linear modeling, allowing assessment of individual and team-level variables, and accounting for the nested data structure. Our results show variance on both the individual and team levels, thus justifying the use of hierarchical linear modeling in our study. Very few studies were able to assess the effect of individual team-leader network variables on team outcomes using hierarchical linear modeling. The joint incorporation of social network measures and hierarchical linear modeling is therefore a unique feature of our study. The second unique feature of our dataset is that we used several individual and team-leader attributes as control variables into our model. Until now, research lacks integrative studies which combine attributes and structural network approaches. Our results indeed show that some of these variables were indeed important predictors. Finally, our assessment of follower innovation adoption was based on multiple sources; multiple residents for each medical specialist assessed the adoption of the structured feedback innovation by the medical specialist. Previous research often used single source assessment, making it more prone for measurement errors.

Despite these new features in leader centrality research, there are still some improvements possible considering the type of data we used. For example, we measured the social network ties for new developments in the team. To generate more richness in the nature of the social networks, future research might include different kinds of ties (e.g., collaboration, trust, and advice relationships) along with variables which can explain the social ties found (e.g., physical proximities and the personal characteristics of the respondents).

Moreover, we focused on adoption within teams of medical specialists regardless of whether the innovation originated inside or outside a specific team. The diffusion process within the teams could be influenced by social networks that medical specialists might have outside their own team, ranging from medical doctors, to nursing staff, management, educationalists, and management consultants, as well as to other support personnel and professional associations. It would be interesting to examine how these networks are composed and what their effects are on the diffusion of healthcare innovations. Finally, we used a cross-sectional research design. A longitudinal approach (combined with simulation methods) could reveal important insights into the dynamics of social networks and leadership.

On a more theoretical level, it should be noted that we did not look into different leadership styles used by the clinical leader, like charismatic leadership styles[39], or the quality of the styles and communication techniques used[40]. Extending the research by focusing on applying different leadership styles by the clinical leader might yield interesting results. Exploring if the leadership style applied by a clinical leader is a consequence or a driver of his/her network position would – for example – be an interesting research question. Note that the focus of the current study was not on leadership style or communication, but on leader centrality, and that we were able to study four different centrality indices in our comprehensive dataset.

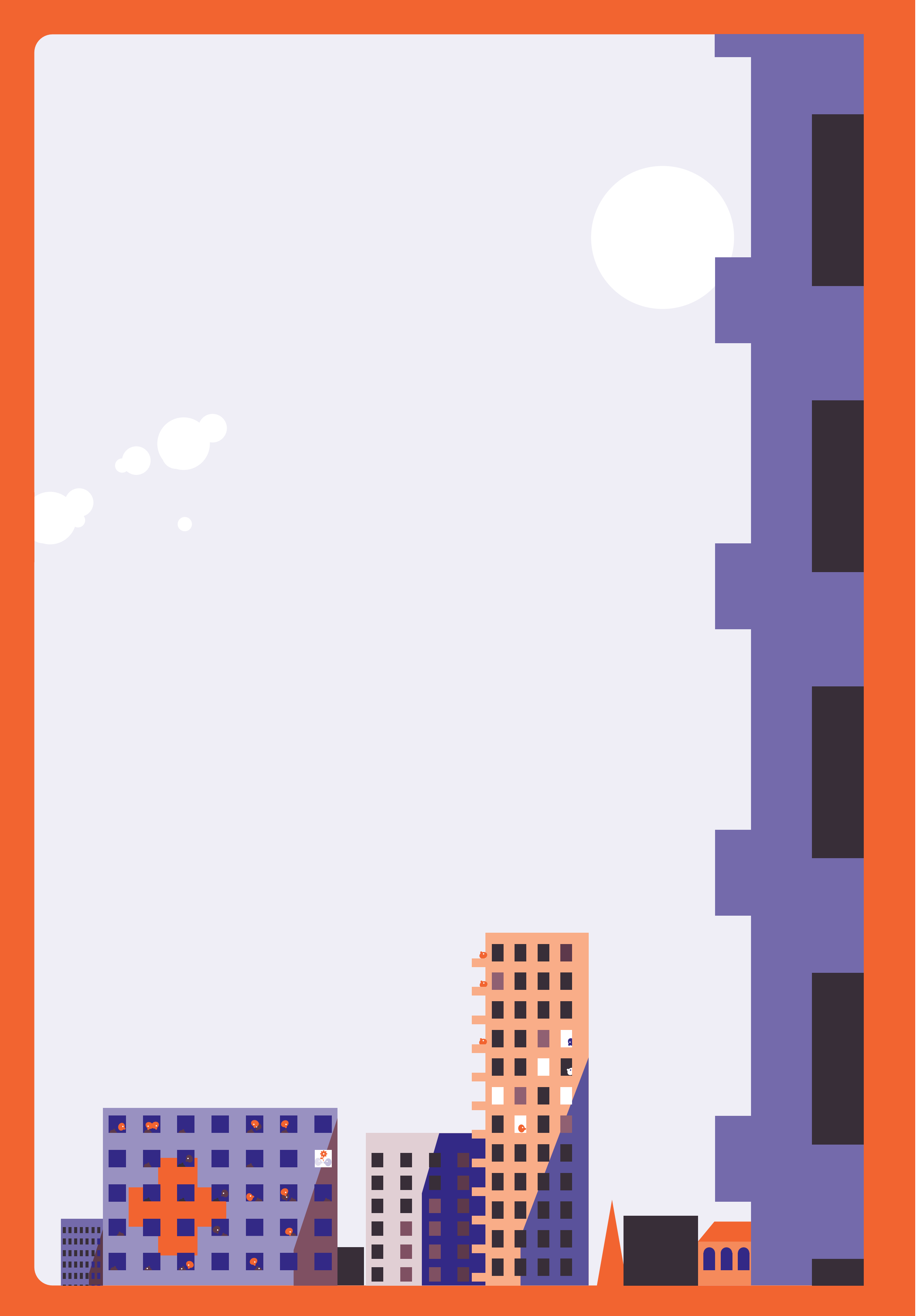
If we want to generalize our results to, we have to take into account that although the medical specialists are formally managed (by law) by the clinical leader, in reality, and typical for a professional Dutch organization, the relationship between the medical specialists and the clinical leader appears to be more collegial than hierarchical. Therefore, some caution is required in generalizing these findings to non-professional organizations, and other countries/cultures. The structured feedback technique can be defined as an incremental medical-educational product innovation introduced into teams of medical specialists. Previous research indicated that competencies needed for successful radical innovation may differ from those needed for successful incremental innovation[41]. Again, this shows the importance of defining the context of the study, as we discussed previously.

Conclusion

The current research aimed to give more comprehensive insights in the role of leader centrality in innovation adoption of followers. Using a dataset with unique features (i.e., large sample size, rich network data, individual attributes as control variables, and multiple sources to measure adoption) made it possible to use advanced analyses to answer our research questions. We hope this study can serve as an example of future research on the influence of leaders' social networks on innovation adoption of followers.

References

1. Barsh J, Capozzi M, Davidson J. Leadership and innovation. *Mckinsey Q.* 2008:36-47.
2. Bel R. Leadership and innovation: Learning from the best. *Glob Bus & Orga Exc*. 2010;29:47-60.
3. Gardner W, Lowe K, Moss T, Mahoney K, Cogliser C. Scholarly leadership of the study of leadership: A review of the leadership quarterly's second decade, 2000-2009. *Lead Q*. 2010;21:922-58.
4. Rogers EM. *Diffusion of innovations*. New York: Free Press; 2003.
5. Wasserman S, Faust K. *Social network analysis*. Cambridge: Cambridge University Press; 1994.
6. Mullen B, Johnson C, Salas E. Effects of communication network structure - components of positional centrality. *Soc Netw.* 1991;13:169-85.
7. West E, Barron DN, Dowsett J, Newton JN. Hierarchies and cliques in the social networks of health care professionals: Implications for the design of dissemination strategies. *Soc Sci & Med*. 1999;48:633-46.
8. Henttonen K. Exploring social networks on the team level - A review of the empirical literature. *J Eng & Techn Man*. 2010;27:74-109.
9. Sparrowe R, Liden R, Wayne S, Kraimer M. Social networks and the performance of individuals and groups. *Acad Man J*. 2001;44:316-25.
10. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach.* 2008;30:248-53.
11. Friedkin N, Slater M. School leadership and performance: A social network approach. *Soc Educ*. 1994;67:139-57.
12. Brass D. Being in the right place: A structural analysis of individual influence in an organization. *Adm Sci Q*. 1984;29:518-39.
13. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q*. 2004;82:581-629.
14. Bandura A. *Social learning theory*. Englewood Cliffs, N.J.: Prentice-Hall; 1977.
15. Bandura A. *Social foundations of thought and action*. Englewood Cliffs, N.J.: Prentice-Hall; 1986.
16. Burt R. Structural holes and good ideas. *Am J Soc*. 2004;110:349-99.
17. Balkundi P, Barsness Z, Michael J. Unlocking the influence of leadership network structures on team conflict and viability. *Small Group Res*. 2009;40:301-22.
18. Mehra A, Kilduff M, Brass D. The social networks of high and low self-monitors: Implications for workplace performance. *Adm Sci Q*. 2001;46:121-46.
19. Jippes E, Luijk SJ, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Barriers and facilitators to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study. *Med Teach* in press. 2012.
20. Feeley T. Testing a communication network model of employee turnover based on centrality. *J Appl Comm Res*. 2000;28:262.
21. Bonacich P. Some unique properties of eigenvector centrality. *Soc Netw*. 2007;29:555-64.
22. Balkundi P, Kilduff M. The ties that lead: A social network approach to leadership. *Lead Q*. 2005;16:941-61.
23. Mehra A, Dixon A, Brass D, Robertson B. The social network ties of group leaders: Implications for group performance and leader reputation. *Org Sci*. 2006;17:64-79.
24. Ibarra H. Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. *Acad Man J*. 1993;36:471-501.
25. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach*. 2007;29:642-7.
26. Archer JC. State of the science in health professional education: Effective feedback. *Med Educ*. 2010;44:101-8.
27. West MA, Anderson NR. Innovation in top management teams. *J Appl Psychol*. 1996;81:680-93.
28. Jippes E, Achterkamp MC, Brand PLP, Kiewiet DJ, Pols J, van Engelen JML. Disseminating educational innovations in health care practice: Training versus social networks. *Soc Sci & Med*. 2010;70:1509-17.
29. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication.* Oxford: Oxford University Press; 2003.
30. Kratzer J, Leenders RTAJ, van Engelen JML. The social structure of leadership and creativity in engineering design teams: An empirical analysis. *J Eng & Techn Man*. 2008;25:269-86.
31. Borgatti SP, Everett MG, Freeman LC. *Ucinet 6 for windows*. Needham, MA: Analytic Technologies; 2002.
32. Ajrouch K, Blandon A, Antonucci T. Social networks among men and women: The effects of age and socioeconomic status. *J Ger Ser B: Psych Sci & Soc Sci*. 2005;60:311-7.
33. Garcia-Goni M, Maroto A, Rubalcaba L. Innovation and motivation in public health professionals. *Health Pol*. 2007;84:344-58.
34. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man*. 2001;19:1-12.
35. Weick C, Martin J. Full-time and part-time independent inventors: Rising with the creative class. *Int J Entr & Inn*. 2006;7:5-12.
36. Neubert M, Taggar S. Pathways to informal leadership: The moderating role of gender on the relationship of individual differences and team member network centrality to informal leadership emergence. *Lead Q*. 2004;15:175.
37. Snijders TAB, Bosker RJ. *Multilevel analysis: An introduction to basic and - advanced multilevel modeling*. London: Sage Publications Ltd; 1999.
38. Inkpen A, Tsang E. Social capital, networks, and knowledge transfer. *Acad Man Rev*. 2005;30:146-65.
39. Paulsen N, Maldonado D, Callan V, Ayoko O. Charismatic leadership, change and innovation in an R&D organization. *J Org Change Man*. 2009;22:511-23.
40. Sarin S, O'Connor G. First among equals: The effect of team leader characteristics on the internal dynamics of cross-functional product development teams. *J Prod Inn Man*. 2009;26:188-205.
41. Brockman B, Morgan R. The moderating effect of organizational cohesiveness in knowledge use and new product development. *J Acad Mark Sci*. 2006;34:295-307.



Chapter 8

Impact of clinical director centrality and network configuration on team member innovation adoption

Erik Jippes
Jan Pols
Marjolein C. Achterkamp
Jo M.L. van Engelen
Paul L.P. Brand

Submitted

Abstract

Social networks and their configuration (segmentation and density) are important for clinical directors (such as the heads of the department or the heads of the clinical teaching unit) to stimulate innovation adoption of their team members. In addition, the extent to which clinical directors are connected within these social networks to their team members (director centrality) affects their abilities to influence and communicate with these members. We studied the effects of clinical director centrality (measured as closeness centrality), team network configuration (measured as density and segmentation), and control variables (gender, age, attitude, length and hours of employment of team members and clinical directors) on team members' adoption of an educational innovation.

Validated questionnaires were collected from 370 medical specialists and 357 residents from 38 teams from different specialties and hospitals in the Netherlands.

In a hierarchical linear model, clinical director's closeness centrality was positively related to team member innovation adoption ($p < .001$), and team network segmentation moderated this relationship positively ($p < .05$). More specifically clinical directors with high closeness centralities were found to be particularly effective for innovation adoption of team members in highly segmented networks. Clinical directors' gender (female leaders), clinical directors' hours of employment, and team member attitude towards the innovation, were also positively associated with team member innovation adoption, but network density was not. Our results suggest that using clinical directors' social network structures may help to facilitate innovation adoption by their team members.

Keywords: Leader centrality, Network configuration, Social capital, Social network, Leadership, Innovation adoption, Healthcare, The Netherlands.

Introduction

Clinical directors (such as heads of the department or heads of the clinical teaching unit) are responsible for setting the medical team's agenda and ensuring team members' performance. To stimulate innovation adoption by the physicians on their teams, the clinical directors' capacities to influence and communicate, as well as their credibility, are more important factors than their hierarchical position in professional bureaucracies, like hospitals[1]. Recently this was also empirically demonstrated in a study investigating the impact of four clinical leader centralities (i.e., the extent to which the leader is connected to his/her team members in the team's social network) on innovation adoption of team members[2]. This confirms earlier observations that collegial mechanisms (such as communication processes between peers) are most important in bringing about change and innovation in healthcare[3].

In addition to the centrality of clinical directors, the network configuration (i.e., the structural characteristics of the social network within which the ties of the director are set) of the directors' teams, impact their efforts to influence their team members towards (higher) innovation adoption. Highly segmented networks (characterized by many subcultures and subgroups) pose different challenges on the clinical directors' efforts to influence their team members towards innovation adoption, than networks which are closely knitted together (highly dense network).

Remarkably, although both high segmentation and high density have frequently been pointed out as troubling the innovation processes in hospitals[4], no studies have examined the possible moderating effects of the network configuration on the "leader centrality-team member innovation adoption" relationship.

Our study aims to fill this gap by examining the moderating role of two network configuration measures; density and segmentation. In order to do this, we set up a multi-level study and gathered comprehensive network data from 38 teams with 370 medical specialists from different hospitals and different medical specialties in the Netherlands.

Theoretical framework and conceptual model

Social networks and centrality

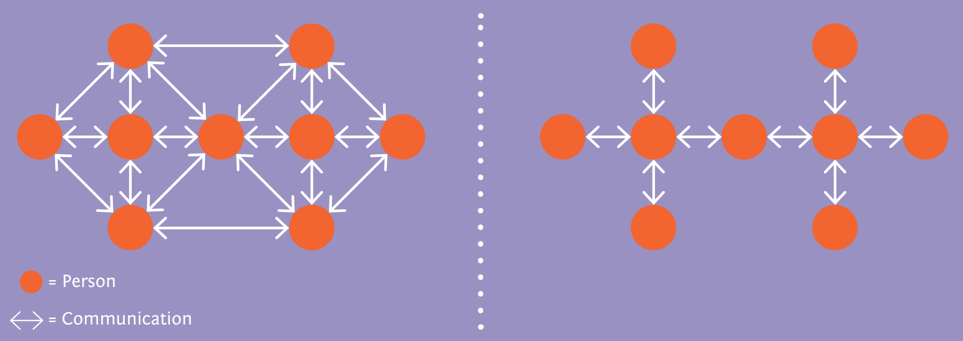
Based on the principle that patterns of relations of people influences outcomes over and above individual and group attributes alone, social network analysts have examined the effects of connections between individuals in networks on the adoption of innovations[5]. Social networks influence diffusion and adoption by functioning as channels for communication, social construction, and negotiation of the innovation; therefore increasing the observability of the innovation and reducing any perceived risk through eliminating any novelty or uncertainty for the potential adopters of the outcome of the innovation[6,7].

A key variable in this network research is centrality: the extent to which an individual is connected to other actors in the network[8]. In this study, clinical director centrality is thus the extent to which the director is connected to other medical specialists in the network. In the past, different types of leader centralities have been defined. We will use leader closeness centrality in our study because a recent study investigating multiple clinical leader centrality indices found this centrality index to be the main predictor for innovation adoption of team members after adjusting for gender, age and attitude towards the innovation[2]. Closeness centrality refers to persons who can quickly interact with the others in the network and have a broad "reach" across the network. Director closeness centrality is computed as the inverse of the sum of the distances from the director to all team members. As distances decrease, the centrality index increases. These directors can be framed as having both direct and indirect ties with their followers[8].

Social learning theory and diffusion theory/models can explain the importance of closeness centrality, according to Jippes et al. (2011). The core idea of the social learning theory[9,10], is that an individual learns through observational modeling: the adopter observes others' behavior and acts in a similar way. This is not simple imitation; in social modeling, the adopter extracts the essential elements from an observed behavioral pattern in order to perform in a similar fashion. Diffusion theory is related to social learning theory. The theories share basic premises, since both seek to explain how individuals change behavior as a result of (verbal and non-verbal) communication with others. Diffusion can be defined as "the process in which an innovation is communicated through certain

Figure 1

Network configuration: (a) highly dense and (b) highly segmented network



channels over time among the members of a social system" (Rogers, 2003, p. 5). Diffusion concerns a two-way process of communication convergence dealing with new ideas. According to Rogers (2003, p. 103) "the diffusion theory/model is a conceptual paradigm with relevance for many disciplines…it provides a common conceptual ground that bridges these diverse disciplines and methodologies." Note that both theories consider information exchange as essential to behavioral change, and stress social network connections as the main predictors[7,9,10].

This information exchange was exactly why Jippes et al. (2011) argued to have found such strong effects for clinical directors high in closeness centrality: Their reach across the networks provides their team members with high exposure to model the desired behavior[2]. Furthermore, leaders demonstrating high closeness centrality are able to make full use of the social network structures in the team that naturally exist to diffuse information about innovations. Finally, these kinds of leaders might be able to spot new ideas, retrieve and control information through their indirect ties with their team members[2].

Moderating role of team network configuration: Density and segmentation

As said before, we argue that the network configuration of the team will have an important moderating influence on the effects of clinical director's centrality. Different challenges are imposed on a clinical director from a highly knitted or dense network than from a highly segmented network with many subgroups. Therefore, we used two network coefficients that measure this "knittedness" of the teams in our analyses: Team network density and team network segmentation (see also Figure 1). Both factors have been found to have *direct effects* on performance and innovation[11,12]. However, we hypothesize that they will have also a *moderating* role by interacting with clinical director closeness centrality. In the next sections, we will describe the theoretical rationale for these hypothesized moderators.

Team network density

Density is the proportion of lines actually present in the network compared to the maximum amount possible (Figure 1)[8]. For example, consider a medium-sized department of around ten pediatricians. These ten pediatricians can be viewed as a social network in which ideas are being exchanged, day-to-day operations are being discussed etc. For this example, we consider the tie "information exchange" and we assume that this tie is "valued" and "nondirectional". Valued means that the tie can be placed on a continuum between, for example, never (score 1), weekly (score 2) and daily (score 3). Nondirectional means that we cannot distinguish the tie from from actor *i* to *j* and vice versa. The maximum amount of lines in this case is 270 (10 actors times 9 times 3). If all ten pediatricians have contact with each other on a weekly basis (180 lines), the resulting network density is .67.

Previous research showing positive linear effects between team network density and innovation outcomes explained these results by means of the closure perspective.

Closure perspective. This holds that high density fosters identification with group members, promotes trust, and facilitates exchange and collective action[13]. Indeed, dense networks created optimal conditions for the exchange of the complex information necessary for innovation in complex organizations[14], and for innovations that contain ambiguous information[15]. High density networks are often characterized by organic structures and collaborative communication, enabling members to have less inhibited communication, and to coordinate their efforts effectively[16]. Dense networks can also prevent opportunism. In these networks, information diffuses rapidly to other actors, and sanctions for deviant behavior can be easily imposed[17]. Networks with high density promote more interaction among their actors, allowing knowledge to be more meaningfully understood and effectively exchanged, combined, and utilized[17]. Dense networks also encourage actors to stick to familiar patterns and isolate members from the outside world. Finally, network density was found to be significantly related to innovation involvement in the automotive industry[11].

Structural hole perspective. Besides these positive effects of team density, other studies, however, found no significant, negative, or even curvilinear effects. The theoretical arguments of these researchers may be traced back to the structural hole perspective, which states that less dense networks are more suitable for new idea penetration into the network. This perspective argues that in contrast to dense (closed) networks, less dense (open) networks possess "structural holes," i.e. people with repeated access to individuals in other networks.

A structural hole indicates that the individuals on either side of a structural hole have access to different flows of information. Maximizing the span of structural holes, or minimizing redundancy between members, is considered to be beneficial for constructing an efficient, information-rich network[18-21]. According to this perspective there may be an optimal level of team network density for innovation adoption. Dense networks reduce obstacles for the coordinated action necessary to implement innovation but pose barriers to new idea generation.

Björk and Magnusson (2009) indeed showed that more within-network connections resulted in a higher proportion of high-quality ideas; however, the most connected groups performed the worst, indicating a certain optimum for within-network connections[22]. This inverse U-shaped relationship was also found by Kratzer, Leenders and Van Engelen (2005) in their study on the influence of frequency of friendly informal contacts on team performance, and by Oh et al. (2004), who studied within-team network closure (as measured by team network density) in an informal socializing network and team performance[23].

Note that the studies on the closure perspective emphasize that high density fosters identification with group members, promotes trust, and facilitates exchange of information and collective action, and that deviant behavior is easily exposed and sanctioned. We believe these arguments align closely with innovation adoption, because, for fast and full adoption, efficient information exchange and high visibility of actions are requirements. In contrast, studies on the structural hole perspective state that more open networks are suitable for idea penetration, access to diverse information, and clearing redundancy. These arguments fit well with the phases prior to innovation adoption, because in order for new innovations to penetrate a group, diverse information is necessary as well as less sanctioning of deviant behavior. Our study concentrates on innovation adoption itself. Therefore, we follow the closure perspective, and expect a positive *direct* linear effect from team network density on innovation adoption.

Moderating effect of team network density. More importantly, we also argue that team network density has a *moderating* effect on the "clinical director centrality-team member innovation adoption" relationship. We expect a positive moderating effect because the positive effects on innovation adoption of clinical directors with high closeness centrality (high reach across the network to stimulate follower medical specialist adoption, and the ability to spot new ideas) and team network density (efficient information exchange, trust and sanctioning of deviant behavior) reinforce each other, as we will explain below.

Both social learning theory and diffusion theory consider information exchange as essential to behavioral change, and stress social network connections as the main predictors and the main channels for transferring information. A dense network has numerous network connections which provide clinical directors with many opportunities to channel information to their team members, discuss the benefits of the innovation and discuss possible obstacles for implementation. This could especially apply to adoption, since adoption is a two-way process of communication between the person planning to adopt and the person that has already adopted[7].

Moreover, because medical specialists are used to discuss medical issues in their regular day-to-day work (diagnosis and treatment of patients), we expect the same behavior in innovation adoption. In addition, the many direct and indirect ties that the high closeness centrality directors have with team members allow them to make full use of the benefits of the high number of network connections in the dense network.

Therefore, we hypothesize that:

Hypothesis 1: *The relationship between the clinical director's closeness centrality and team members' innovation adoption is positively moderated by the team's team network density; i.e. the relationship between the clinical director's closeness centrality and innovation adoption is positive and stronger under conditions of high density.*

Team network segmentation

Where network density represents the number of network connections *within* the team, network segmentation represents the way these connections are distributed *across* the team. Highly segmented networks contain many subgroups with high within-group and low between-group densities. The social distances or shortest paths between persons not directly tied are greater in more segmented networks (see Figure 1). For example, consider the previous described pediatrics department. The social network in this department would be highly segmented if two subgroups existed in the department of five pediatricians each, of which each subgroup has contact with each other on a daily basis whereas the contact between persons in different subgroups is once a month. Subgroups within a social network are formed based on business demands, social similarities, proximity, profession, complementary needs or goals, ease of communication, and homophily[24].

We propose that the network segmentation influences the relationship between director closeness centrality and the innovation adoption of the team members.

We found no studies that empirically assessed the *moderating* effects of team network segmentation on the "clinical director centrality-team member innovation adoption" relationship, and few studies which empirically assessed the *direct* effect of team network segmentation on performance outcomes. These studies show that team network segmentation can be both detrimental and beneficial to innovation adoption.

Negative effects of team network segmentation. A highly segmented network can oppose effective knowledge sharing, reduce the build-up of knowledge bases and mutual learning when information can only flow through a limited set of persons and may be obstructed by subgroup barriers[25]. Furthermore, subgroups are able to create their own norms (cultural uniformity), jargon, and coding schemes which hamper communication between subgroups[25]. For example, persons who were less central in the network tended to concentrate on identity structures within subgroups, whilst persons who were more central in the network concentrated on identity structures across subgroups[26]. Compliance with norms between subgroups is also difficult due to the limited visibility of actions and their exposure to the whole network[25]. In addition, we argue that segmented networks may also be vulnerable, because removing any of the key individuals could break up the entire social network.

These possible negative effects are supported by a study of Balkundi and Kilduff (2005). They hypothesized that network cliquishness (comparable to team network segmentation) would negatively impact the leader's effectiveness. Formal team leaders are vulnerable to cross-pressures from cliques or subgroups to which they belong. Subgroups may have dissimilar interpretations which can place the formal leader, linking the subgroups, in a complicated situation. Each subgroup can present possibly conflicting demands which may be difficult to meet[27,28].

Positive effects of team network segmentation. On the other hand, segmentation may be beneficial to innovation diffusion and adoption. Kincaid (2004) introduced the concept of "bounded normative influence" to explain how a minority can convince the majority of the benefits of a particular innovation and of how an innovation can be diffused throughout a network. Within bounded local subgroups, the innovation can be embraced and adopted. By gradually decreasing the boundaries of a subgroup (or increasing the size of a subgroup) or by penetrating other subgroups, the innovation can diffuse and ultimately be adopted by the network as a whole[29]. Cohesive subgroups can also amplify information. The subgroup receives the information, boosts the signal strength, and sends the information into the wider population[30].

Henttonen et al. (2010) studied network fragmentation (as measured by the number of components or cliques divided by the number of nodes in the network, comparable to team network segmentation) and team performance for 76 work teams in a variety of sectors. They found the higher the fragmentation, the higher the performance. This finding was attributed to the positive effect of efficiency through division of labor and the neutralizing effect of fragmentation on poor performers. In other words, proper team network segmentation can be efficient. Information can be distributed to a few central individuals in every subgroup who can then spread the information to the rest of the subgroup[12].

We argue that network segmentation has a positive *direct* linear effect on innovation adoption. A segmented network contains subgroups with high within-subgroup densities. These subgroups provide the conditions for high innovation adoption according to the "closure perspective" as mentioned in the previous section on network density (high density fosters identification with group members, promotes trust, and facilitates exchange of information and collective action, and deviant behavior is easily exposed and sanctioned).

Moderating effects of team network segmentation. More importantly, in addition to these direct effects of team network segmentation on innovation adoption, we argue that segmentation *moderates* the "clinical director centrality-team member innovation adoption" relationship. Clinical directors with high closeness centralities have a broad reach across the network; they have both direct and indirect ties to their team members. In a segmented network, direct ties exist within subgroups, and indirect ties between subgroups. The clinical director with high closeness centrality can benefit of the potential positive effects of both ties. Due to their high reach across the network and their direct ties, these directors facilitate observational modeling by team members, and are able to use the natural diffusion capacities of the social network in the team. They are also able to foster support within a subgroup due to their direct ties, and through their indirect ties they can gradually increase the boundary of the subgroups or connect the subgroups.

Therefore, we hypothesize that:

Hypothesis 2: *The relationship between the clinical director's closeness centrality and team members' innovation adoption is positively moderated by the team's network segmentation; i.e. the relationship between the clinical director's closeness centrality and innovation adoption is positive and stronger under conditions of high segmentation.*

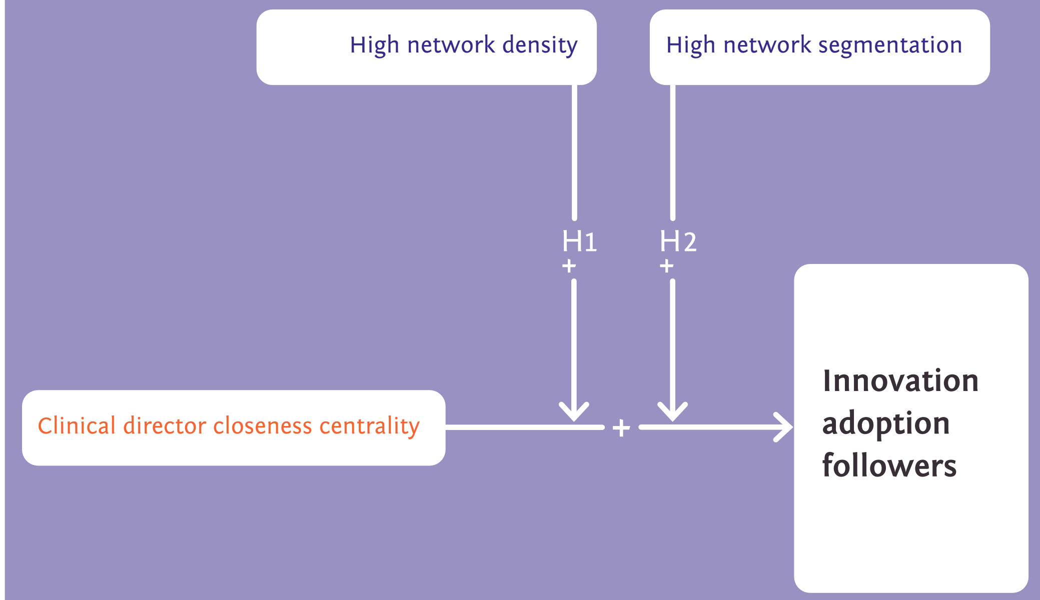
Figure 2 provides a summary of our hypotheses (conceptual model).

Methods

Research context

We used data on innovations introduced in Dutch postgraduate medical specialist training programs. There are 27 postgraduate medical training programs in the Netherlands. In 2004, the Royal Dutch Medical Association (RDMA) – a national board responsible for legislation on postgraduate medical specialist training – introduced competency based education in postgraduate training throughout the Netherlands[31]. In competency based education, medical specialists are trained according to a set of seven core competencies: medical expert, collaborator, communicator, professional, health advocate, management, and scholar[32]. The RDMA introduced a key innovation to support competency based education; structured and constructive feedback.

Figure 2
Summary of hypotheses



Historically, postgraduate training in the Netherlands was characterized mainly by "learning on the job," and neither the method nor the frequency of feedback was structured. Evaluation of the progress of residents (medical specialists in training) was, therefore, rather informal. Before 2004, feedback in postgraduate medical specialist training programs, if offered at all, was given in an unstructured and sometimes derogatory manner. In a recent pilot project related to the implementation of new postgraduate medical specialist training programs, both residents and medical specialists indicated that the introduction of such structured and constructive feedback was the most important innovation in the renewed curricula[33].

The use of this innovation by medical specialists was mandated by the RDMA, and considerable effort was invested by this organization in promoting the benefits of the innovation. These benefits include that if feedback takes place in a safe, timely, specific, and well-structured way, this assessment can be a valuable supervisory and learning mechanism[34]. Information about the innovation was sent by the RDMA to the program director (the medical specialist responsible for the training program of residents in a department), who was responsible for diffusing this information to the other medical specialists within the team. So for proper adoption, the RDMA relied heavily on the peer-to-peer network effects between the program directors and their team members (these are the medical specialists in the team that train residents according to the training program). Earlier research confirmed the importance of social networks in clinical leadership and dissemination strategies[35]. Therefore, we expect these network effects to be important in the adoption of the innovation, which in this context was "structured and constructive feedback".

The structured feedback technique was new and highly innovative for the medical community in the hospitals. For the medical specialists, this innovation consisted of a considerable shift from existing practice[33]. We therefore consider introducing structured and constructive feedback to be a genuine innovation, as whether or not something can be considered an innovation is dependent on the "newness" for the adopting organization[36]. Note that something can be new and innovative for one organization, whereas other organizations have already adopted it. Within our context studied, the innovation was indeed new.

The innovations were to be adopted by all medical specialist teams that train residents. Our study focused on the adoption of "structured and constructive feedback" by medical specialists. This had been developed nationally and some 200 teams of medical specialists needed to adopt it. We assessed the effect that the centrality of the program director (in this paper referred to as clinical director) had on the adoption of the educational innovation by the medical specialists in the program director's team (in this paper referred to as team members), while moderating for team network density and team network segmentation.

Sample

Data were gathered between 2007 and 2010 from 24 radiology teams (diagnostic discipline), 4 obstetrics & gynecology (O&G) teams (surgical), 5 pediatric teams (medical), and 5 anesthesiology teams (supportive discipline) in the Netherlands. The total number of teams and clinical directors was 38. The total sample included 613 medical specialists (370 radiologists, 50 gynecologists, 46 pediatricians, and 147 anesthesiologists) and 571 residents (344 in radiology, 50 in O&G, 36 in pediatrics, and 141 in anesthesiology). From the total sample of 613 medical specialists, 420 responded to the questionnaire (69%). After discarding questionnaires with incomplete answers, a total of 370 (60%) were analyzed. From the total sample of 571 residents, questionnaires from 357 respondents (63%) were included.

Questionnaire

The medical specialists and residents received a structured and validated questionnaire[37]. For the medical specialists, the questionnaire included questions about the independent variables and control variables (described below). The questionnaire for the residents included questions about the dependent variable (structured constructive feedback by medical specialists).

Dependent variable: Team member innovation adoption

The dependent variable in this study is the adoption by medical specialists of the innovation "structured and constructive feedback", which is based on "Pendleton's rules"[38]: the medical specialist (1) provides feedback in a structured fashion, (2) gives the resident the opportunity to give his/her opinion, (3) provides positive points, (4) provides specific points for improvement, and (5) provides the feedback in a safe (constructive) way. The residents were asked to rate each of the five components of Pendleton's feedback rules as provided by the medical specialist (the residents) encountered during a 6-month period, on a 5-point Likert scale, ranging from "totally disagree" to "totally agree", including the possibility to assign "not possible to assess this supervising medical specialist". The items were being worded as "the supervising medical specialist provides feedback in a structured way", "the supervising medical specialist gives me the opportunity to give my opinion on my performance", etc. Only supervising medical specialists who had been assessed by at least two residents were included in data analysis, and the arithmetic average of the residents' answers for each medical specialist on all five points was used as the coefficient for individual innovation adoption of structured feedback by the medical specialists.

Independent variables

Social network data preparation

We focused on information exchange networks and, more specifically, on the "communication innovation network", because these networks were found to be a conduit for innovation diffusion and adoption[7,8]. Following standard practice for network analysis, each medical specialist received a list with all names of their fellow medical specialists (including the clinical director) in his/her team and rated the intensity of "communication in the past half year about the introduction of innovations, new methods or procedures, or new developments related to the work situation" on a six-point scale ranging from "never," to "less than once a month," "more than once a month," "weekly," "daily," or "more than once daily" (also used by[39]). We used UCINET VI[40] to analyze the data.

The answers given by the respondents produced a directed valued matrix. In order to compute closeness centrality, the data needed to be transformed into an undirected dichotomous (symmetric) matrix. The maximum symmetrizing method was used to convert the directed matrix into an undirected one and to correct for missing network data. In this method, the highest rating of communication intensity between two persons was used, or, in the case of missing network data, the rating from one person. To dichotomize the valued matrix (ranging from 1 to 6), we recoded the values one and two into zero (no communication), and the values three, four, five, and six into one (communication relationship).

Clinical director closeness centrality

After preparation of the social network data, we computed closeness centrality. Closeness centrality refers to persons who can quickly interact with all others; these actors can be very productive in communicating information to others in the network[8]. The index is the inverse of the sum of the distances from actor *i* to all other actors. As distances decrease, the centrality index increases. We standardized this index, computed it for every program director and inserted it into the models as the main effect.

Team network density

Density can be defined as the proportion of possible lines to the maximum amount possible, that are actually present in the network[8]. For every team we calculated the team network density using the valued network data, and we used this coefficient to test Hypotheses 1.

Team network segmentation

We computed team network segmentation of the social network using the concept of cliques. A clique can be defined as a maximal complete subgraph of three or more nodes[8]. For every team we calculated the number of cliques and standardized the number by the team size. We used this coefficient to test Hypotheses 2.

Control variables

We controlled for the effect of gender, age, attitude, length of employment, and hours of employment of the *team members* and the *clinical director* (all specified below). Social networks among men and women differ in complex ways, particularly in relation to life stage. Older people tend to have larger and older networks which are less geographically proximal[41]. Balkundi and Kilduff (2005) hypothesized that the moderating role of team network density on the “leader – team effectiveness” relationship would be dependent on the attitude of the team member. Medical specialists rated the question, “Structured feedback is an improvement in the quality of postgraduate medical specialist training,” on a five-point Likert scale ranging from “totally disagree” to “totally agree.”

Research showed that the longer a person worked in an organization, the more negative the scoring on job satisfaction, the effect of budget adjustments on individual job-related stress, the quality of individual performance, and department morale[42]. No significant differences between part-time and full-time “inventors” were found in earlier research[43], but since an increasing number of health-care professionals have part-time appointments, this variable was included.

Data analysis

We analyzed the reliability and validity of our dependent variable and we conducted a correlation analysis to check for bivariate patterns in the data. To account for the nested structure (individuals within teams) of the data, we conducted a two-level hierarchical linear model (Level 1 for the individual and Level 2 for the teams). Applying hierarchical linear modeling permits testing influence of team-level variables on individual-level variables without biasing the standard error estimates[44].

The *team member* and *clinical director* control variables were entered into the model first. We entered the centrality index into the model to assess the individual contribution of this index to the model. Next, to assess the formulated interaction hypotheses, we inserted the interaction effects along with the main effects of the centrality index, team network density and team network segmentation. We entered team network density and team network segmentation simultaneously, because both characterize the network configuration which the leader is supposed to lead. The individual control variables were inserted on the individual level (Level 1) and the other variables (clinical director control variables, clinical director independent variables, and the interaction effects) on the team level (Level 2).

Because their distributions were skewed, the control variables age (minus 30 percentage points), attitude (minus 1 percentage points), and hours of employment (minus 15 percentage points), were centered before they were entered into the model. Centering improves model interpretation[45]. To test whether innovation adoption could be attributed to the type of specialism (O&G, pediatrics, radiology, anesthesiology), we entered this as a categorical variable into all models. Nowhere was type of discipline significantly related to our dependent variable; therefore, pooling data across the disciplines was justified. Finally, to avoid misinterpretation, we tested for possible curvilinear relationships between the clinical director centrality index and innovation adoption (as found by[39]).

Table 1

Descriptive statistics and correlations for individual-level variables

	N	Scale used	Min.	Max.	Mean	SE	1	2	3	4	5
Dependent variable											
1. Team member innovation adoption	370†	1-5	1.90	5.00	4.06	.47					
Individual team member control variables											
2. Gender	370†						*-.02*				
Males	261										
Females	109										
3. Age	370†	Years	30.00	65.00	46.75	8.39	*-.14***	*-.21***			
4. Attitude	370†	1-5	1.00	5.00	4.27	.85	*.07*	*.10*	*-.01*		
5. Hours of employment (part-time/full-time)	370†	%	15.00	100.00	92.00	14.37	*.10*	*-.31***	*-.09*	*-.06*	
6. Length of employment	370†	Years	.00	35.00	10.45	8.33	*-.10*	*-.22***	*.78***	*.05*	*.01*

† This variable is on the individual level (Level 1); this N therefore represents the number of team members (medical specialists)

* $p < .05$

** $p < .01$

Table 2

Descriptive statistics and correlations for team-level variables

	N	Scale used	Min.	Max.	Mean	SE	1	2	3	4	5	6	7
Clinical director control variables													
1. Gender	38†												
Male leaders	35												
Female leaders	3												
2. Age	38†	Years	36.00	61.00	48.47	6.35	*-.11*						
3. Attitude	38†	1-5	1.00	5.00	4.30	.98	*-.01*	*-.02*					
4. Hours of employment (part-time/full-time)	38†	%	70.00	100.00	96.43	8.10	*-.34**	*.28*	*.11*				
5. Length of employment	38†	Years	1.00	25.00	11.39	6.72	*-.08*	*.75***	*.08*	*.07*			
Team network independent variables													
6. Clinical director closeness centrality	38†	0-100	9.36	100.00	55.59	29.56	*-.10*	*.13*	*-.05*	*.21*	*.06*		
7. Team network density	38†	Number	.93	3.77	2.22	.69	*.09*	*.18*	*-.06*	*.30*	*.23*	*.35**	
8. Team network segmentation	38†	Number	.00	1.28	.50	.32	*.04*	*.21*	*.20*	*.14*	*.17*	*-.09*	*.13*

† This variable is on the team level (Level 2); this N therefore represents the number of clinical directors of teams.

* $p < .05$

** $p < .01$

Table 3

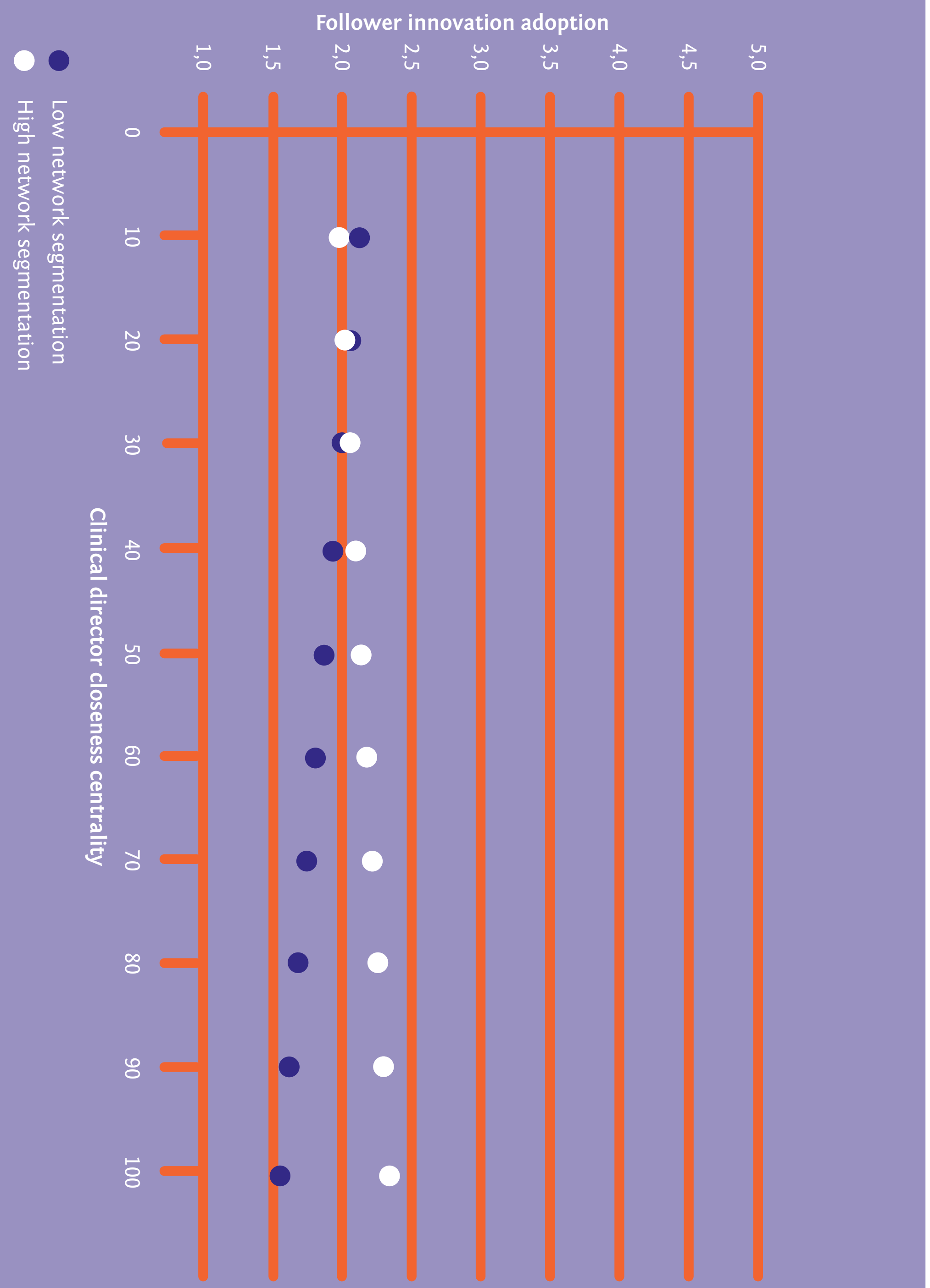
Hierarchical linear model for follower innovation adoption

	Model 0	Model 1 Control variables	Model 2 Main effect	Model 3 Hypotheses 1 and 2
Constant	4.098 (.065)	3.358 (.488)	2.088 (.558)	2.088 (.558)
Individual control variables				
Gender (male is reference category)		-.005 (.056)	.023 (.054)	.017 (.054)
Age		-.007 (.004)	-.008 (.004)	-.008 (.004)
Attitude		.047 (.028)	.043 (.027)	.055 (.026)*
Hours of employment		.003 (.002)	.002 (.002)	.003 (.002)
Length of employment		-.001 (.004)	-.001 (.004)	-.001 (.004)
Clinical director control variables				
Director gender (male is reference category)		.111 (.139)	.565 (.167)**	.735 (.200)**
Director age		<.000 (.008)	-.003 (.008)	-.013 (.009)
Director attitude		-.001 (.026)	.022 (.026)	.019 (.030)
Director hours of employment		.004 (.006)	.018 (.006)**	.022 (.007)**
Director length of employment		.008 (.007)	<.000 (.001)	.005 (.008)
Independent clinical director closeness centrality variable				
Clinical director closeness centrality			.005 (.001)**	-.007 (.004)
Independent interaction effects				
Team network density				-.128 (.163)
Team network segmentation				-.203 (.232)
Interaction clinical director closeness centrality and team network density				.003 (.002)
Interaction clinical director closeness centrality and team network segmentation				.009 (.005)*
Variance				
Level 1 individual	.197 (.001)	.186 (.014)	.172 (.013)	.164 (.012)
Level 2 team	.045 (.022)	.053 (.025)	.164 (.067)	.210 (.008)
Explained variance				
Level 1 individual		5.54%	12.86%	17.01%
Level 2 team		0.00%	0.00%	0.00%
-2 Log likelihood	471.021	452.319	437.855	423.826

* $p < .05$

** $p < .01$

Figure 3
Moderating effect of team network segmentation on "clinical director closeness centrality"



Results
Reliability analysis yielded a Cronbach's alpha of .85 for the five questions that measured the dependent variable "structured and constructive feedback." Factor analysis revealed one construct under these questions (eigenvalue of 3.147 and 63% explanation of variance). The assumptions for factor analysis were met. There was no multicollinearity; the Kaiser-Meyer-Olkin measurement was .797 and Barletts' test was significant ($p < .01$). In Tables 1 and 2, the descriptive statistics and correlation analyses for the individual variables (Table 1) and the team-level variables (Table 2) are presented.

Correlation analysis
With respect to the individual level variables, significant correlations were found between innovation adoption and age (older specialists had lower innovation adoption), gender and age (males were older), gender and hours of employment (males worked more hours), gender and length of employment (males worked longer in the hospital) and age and length of employment (older specialists worked longer in the hospital). At the team level, director's gender was significantly related to hours of employment (male directors worked more hours). Director's hours of employment and length of employment showed a positive correlation as well as clinical director's centrality and team network density (Tables 1 and 2).

Hierarchical linear model
Table 3 shows the results of the regression analysis. The null model showed most variance on the individual level, followed by the team level. None of the control variables in Model 1 were significantly related to team member innovation adoption. In Model 2, we entered clinical director closeness centrality. This significantly improved the model's fit (12.86% explained variance). Clinical director closeness centrality had a significantly positive relationship ($p < .01$) with team member innovation adoption. Team network segmentation had a significantly positive interaction effect with clinical director leader closeness on innovation adoption ($p < .05$) in Model 3 (17.01% explained variance). This supports our Hypothesis 2, i.e., a positive moderating effect. More specifically, the relationship between clinical director centrality and team member innovation adoption is positive and stronger under conditions of high network segmentation (see Figure 3). In other words, the clinical director with high centrality is particularly effective for innovation adoption of team members in a highly segmented network. However, Model 3 did not show a significant (interaction) effect of team network density (p's $> .10$).

Models 2 and 3 also showed significantly positive relationships for director's gender (male = reference category) and director's hours of employment with team member innovation adoption. In addition, attitude of team members was related to team member innovation adoption in model 3. The findings led us to accept Hypothesis 2 and to reject Hypothesis 1 (we found no significant effect for team network density). The analyses for possible curvilinear relationships between the clinical director centrality index and team member innovation adoption revealed no such relationship (β = -.000045 (.000067)).

Discussion

This study examined the moderating effects of two network configurations on the relationship between clinical director centrality (as measured by closeness centrality) and team member innovation adoption. Clinical director closeness centrality had a significantly positive relationship with team member innovation adoption, and this was positively moderated by team network segmentation. In addition, clinical director's gender (female leaders), director's hours of employment, and team members' attitude were significantly positively related to team members' innovation adoption. These findings were in line with our Hypothesis 2 which stated a positive effect from team network segmentation on clinical director closeness centrality.

Team network configuration

We found a significant moderating effect for team network segmentation on the "clinical director centrality-team member innovation adoption" relationship. More specifically clinical directors with high closeness centralities are particularly effective for innovation adoption of team members in a highly segmented network. This finding is particularly interesting because previous studies only examined direct effects. Henttonen et al. (2010), for instance, found a significantly positive direct relationship between network fragmentation (comparable to team network segmentation) and team performance. The moderating effect found in our study could be explained as follows. In a segmented network, direct ties exist within the subgroups and indirect ties between the subgroups. A clinical director high in closeness centrality can enhance the potentially positive effects of both, this may explain why we found a positive effect for clinical directors high in closeness centrality under conditions of high segmentation. Clinical directors with high closeness centralities are highly visible and active due to their direct ties, which could lead to observation and possibly adoption by team members. Due to their direct ties they are able to grow support within a subgroup, and through their indirect ties they can gradually increase the boundaries of the subgroups or connect the subgroups.

We found, however, no moderating effect of team network density on the "clinical director centrality-team member innovation adoption" relationship. It seems that within the medical community, team network density has no (moderating) effect influence on team member adoption. One possible explanation is that already some degree of connectedness between team members is sufficient to channel information exchange, and spread clinical directors' behavior patterns and influence to their members. Another explanation is that team network density influences the innovation diffusion *speed*. The "closure perspective" holds that high density fosters identification with group members, promotes trust, and facilitates exchange of information and collective action[13]. It may be that high density influences the speed of information exchange and behavioral modeling inside the network. We measured innovation adoption cross-sectionally; a longitudinal approach may shed more light on this hypothesis.

Clinical director centrality

As expected, our study showed that clinical directors with high closeness centrality had team members with higher adoption patterns. This is in agreement with earlier work on clinical leader centrality and innovation adoption[2] and can be explained by social learning theory and diffusion theory. Both theories emphasize the importance of visibility of the team leader and exposure to the primary adopters, in order for followers to observe, exchange information, capture the essence, and apply the innovation themselves. Direct ties through closeness centrality may provide the necessary visibility and exposure. Another explanation could be that the visibility and exposure of high closeness clinical directors provide their medical specialists followers with accessibility to discuss the benefits of the innovation. This would particularly apply to innovation adoption because this concerns a two-way process of communication, rather than a one-way, linear act in which one individual seeks to transfer a message to another[7]. Because medical specialists are used to discuss medical issues in their regular day-to-day operations, we could expect the same behavior in adopting innovations.

Individual and formal team leader control variables

Medical specialists with a more positive attitude towards the innovation were more likely to properly apply it. This confirms the importance of positive motivation and attitude for the adoption of innovations in healthcare[46]. Some of the clinical director control variables were also significantly related to team member innovation adoption. The few female leaders were found to obtain higher innovation adoption within their teams. The fact that there were only three female leaders in our sample may have resulted in a high intrinsic motivation to set an example, and perform at a high level. However, the small number of female leaders in our sample itself calls for caution in interpreting these particular results. Furthermore, medical specialists working with clinical directors who worked more hours (per week) were more likely to adopt the innovation. It could be that these clinical directors were more visible and more available to team members, which gave team members more opportunities to observe their leader's adoptive behavior and thus feel more compelled to apply the innovation.

Strengths, limitations, and directions for further research

Our study is – to our knowledge – the first to empirically assess the impact of clinical director centrality with moderating network configuration effects on team member innovation adoption. Our sample size has made it possible to use hierarchical linear modeling, allowing assessment of individual and team level variables, and accounting for the nested data structure. Our results show variance on both the individual and team levels, justifying the use of hierarchical linear modeling in our study. The joint incorporation of social network measures and hierarchical linear modeling is a unique feature in our research. Research on clinical leadership may benefit by incorporating social network coefficients preferably as independent variables, but at least as control variables.

Despite of having this comprehensive dataset, this study also had limitations. First, the diffusion process within the teams could be influenced by social networks with other doctors, nursing staff, management, educationalists, management consultants, other support personnel and professional associations. It would be interesting to examine how these networks are composed and what their effects are on the diffusion of healthcare innovations. Second, we used a cross-sectional research design. A longitudinal approach (combined with simulation methods) could reveal important insights into the dynamics of social networks and leadership. Third, although the medical specialists are formally managed (by law) by the program director (in this paper referred to as clinical director), in reality, as typical for a Dutch professional organization, the relationship between the medical specialists and the program director appears to be more collegial than hierarchical. Therefore, some caution is required in generalizing these findings to non-professional organizations and other countries/cultures. Finally, our study was limited to innovation in medical training. Caution is needed in generalizing the findings from this study to innovation in healthcare as a whole.

Conclusions and implication of the results

Our results point to the importance of the social capital benefits that clinical directors may yield from being well embedded in their teams' social network. This means that clinical directors may benefit from the aggregate of resources embedded within, available through, and derived from the network of relationships[47]. In particular, the network configuration, in which the structural ties of the clinical director are set, may influence the leader's capabilities in terms of innovation adoption of team members. For high team member innovation adoption, clinical directors need to attain high central network positions according to closeness centrality. These positions may provide the direct ties and visibility necessary for team member innovation adoption. According to our results, high segmentation – a phenomenon often observed in hospitals – is not necessarily a problem for innovation adoption. In fact, our results show that in departments characterized by high segmentation, leadership by high closeness centrality clinical directors can make a difference. The clinical director can foster support for the innovation in the different subgroups and by gradually increasing the size of the subgroups, the whole team can be "contaminated" with the innovation. Our result support the notion that leader centrality cannot be studied in isolation; the structural network configuration of the leader's team also has to be taken into account.

From a managerial point of view, it could be worthwhile to recognize, consider, and actively engage the clinical director's network position and overall network configuration. Structural social network measures that a clinical director can consider include: adding or removing team members, introducing job rotation schemes, and altering the frequency of team meetings. After identification of the network structures using social network analysis, these can be harnessed for optimal diffusion and adoption of innovations. To increase the natural diffusion rate and level of adoption (caused by the social network structures), it would be worthwhile for management to add additional process measures. Possible process measures would include project management tools, inviting experts, and organizing peer supervision meetings to share knowledge and evaluate individual and team performance.

The current research aimed to give more comprehensive insights into the moderating role of network configuration on the “clinical director centrality-team member innovation adoption” relationship. Using a dataset with unique features (i.e., large sample size, rich network data, individual attributes as control variables, and multiple sources to measure adoption) allowed us to use advanced analyses to answer our research questions. We hope this study can serve as an example of future research on the influence of clinical leaders’ social networks on innovation adoption of team members.

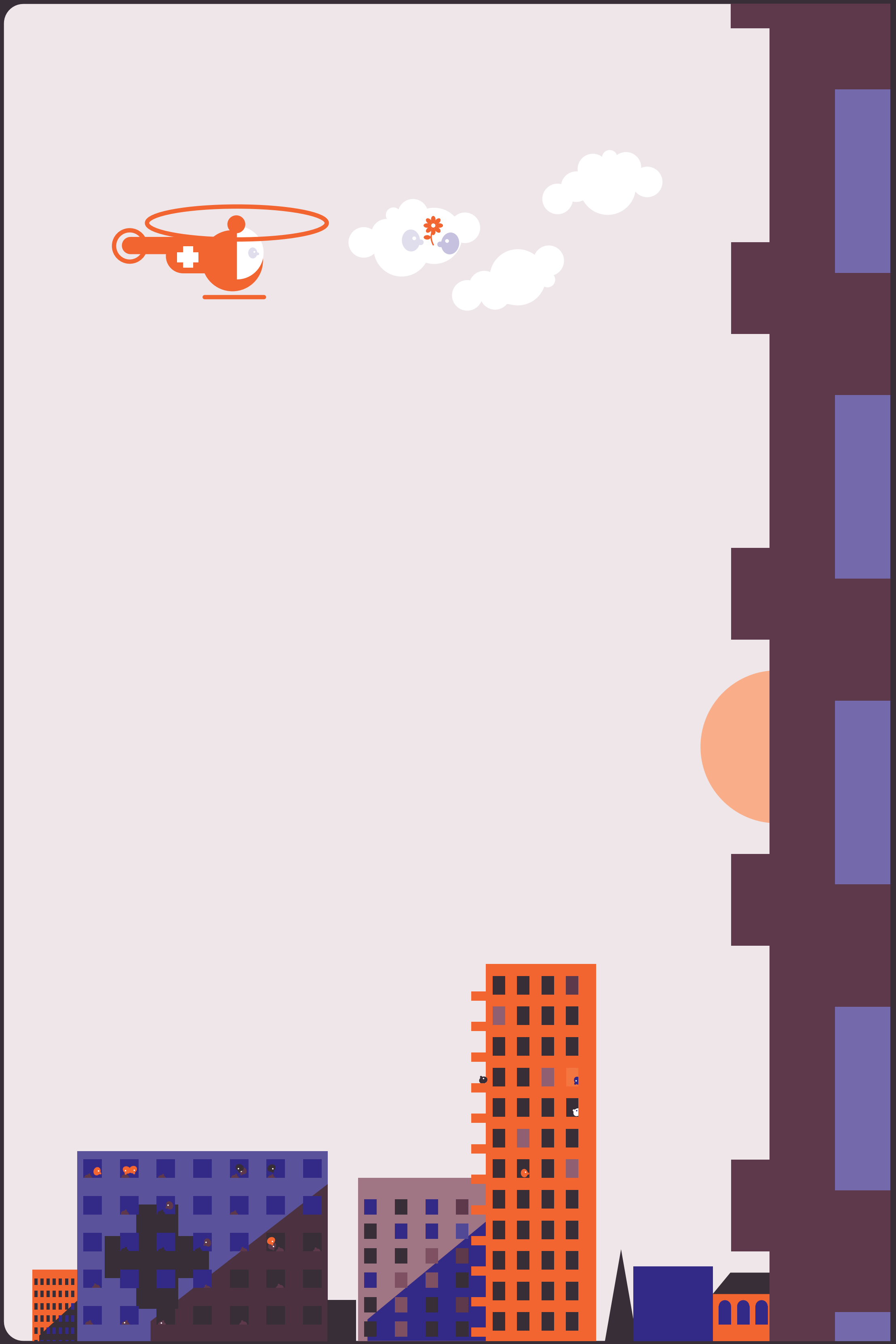
Acknowledgements

We thank Yvonne Steinert and Marijke Leliveld for their critical reading of the manuscript.

References

1. Dickinson H, Ham C. *Engaging doctors in leadership: Review of the literature.* Birmingham: Health Services Management Centre, University of Birmingham; 2008.
2. Jippes E, Achterkamp MC, Pols J, Leliveld MC, Brand PLP, van Engelen JML. Impact of clinical leader centrality on followers’ innovation adoption. *Submitted*. 2012.
3. Mintzberg H. *The structuring of organizations*. Englewood Cliffs: Prentice-Hall; 1979.
4. Mintzberg H. Toward healthier hospitals. *Health Care Man Rev*. 1997;22:9-18.
5. Baldwin T, Bedell M, Johnson J. The social fabric of a team-based M.B.A. program: Network effects on student satisfaction and performance. *Acad Man J*. 1997;40:1369.
6. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q*. 2004;82:581-629.
7. Rogers EM. *Diffusion of innovations*. New York: Free Press; 2003.
8. Wasserman S, Faust K. *Social network analysis*. Cambridge: Cambridge University Press; 1994.
9. Bandura A. *Social learning theory*. Englewood Cliffs, N.J.: Prentice-Hall; 1977.
10. Bandura A. *Social foundations of thought and action*. Englewood Cliffs, N.J.: Prentice-Hall; 1986.
11. Obstfeld D. Social networks, the tertius iungens orientation, and involvement in innovation. *Adm Sci Q*. 2005;50:100-30.
12. Henttonen K, Janhonen M, Johanson JE, Puumalainen K. The demographic antecedents and performance consequences of the social-network structure in work teams. *Team Perf Man*. 2010;16:388-412.
13. Coleman J. Social capital in the creation of human capital. 1988;94:95-120.
14. Hansen M. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Org Sci*. 2002;13:232-48.
15. Gibbons D. Network structure and innovation ambiguity effects on diffusion in dynamic organizational fields. *Acad Man J*. 2004;47:938-51.
16. Brockman B, Morgan R. The moderating effect of organizational cohesiveness in knowledge use and new product development. *J Acad Mark Sci*. 2006;34:295-307.
17. Ahuja G. Collaboration networks, structural holes, and innovation: A longitudinal study. *Adm Sci Q*. 2000;45:425-55.
18. Granovetter M. The strength of weak ties: A network theory revisited. *Soc Theory*. 1983:201.
19. Granovetter M. The impact of social structure on economic outcomes. *J Econ Perspect*. 2005;19:33-50.
20. Burt R. *Structural holes*. Cambridge, MA: Harvard University Press; 1992.
21. Burt R. Structural holes and good ideas. *Am J Soc*. 2004;110:349-99.
22. Björk J, Magnusson M. Where do good innovation ideas come from? exploring the influence of network connectivity on innovation idea quality. *J Prod Inn Man*. 2009;26:662-70.

23. Oh H, Chung MH, Labianca G. Group social capital and group effectiveness: The role of informal socializing ties. *Acad Man J*. 2004;47:860-75.
24. Baerveldt C, Snijders T. Influences on and from the segmentation of networks: Hypotheses and tests. *Soc Netw*. 1994;16:213-32.
25. Kratzer J. *Communication and performance*. Groningen: ICS; 2001.
26. Kuhn T, Nelson N. Reengineering identity: A case study of multiplicity and duality in organizational identification. *Man Comm Q*. 2002;16:5-34.
27. Krackhardt D. The ties that torture: Simmelian tie analysis in organisations. *Res Soc Org*. 1999;16:183-210.
28. Balkundi P, Kilduff M. The ties that lead: A social network approach to leadership. *Lead Q*. 2005;16:941-61.
29. Kincaid DL. From innovation to social norm: Bounded normative influence. *J Health Comm*. 2004;9:37-57.
30. Moody J, White D. Structural cohesion and embeddedness: A hierarchical concept of social groups. *Am Sociol Rev*. 2003;68:103-27.
31. Scheele F, Teunissen P, van Luijk S, Heineman E, Fluit L, Mulder H, et al. Introducing competency-based postgraduate medical education in the Netherlands. *Med Teach*. 2008;30:248-53.
32. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach*. 2007;29:642-7.
33. Jippes E, Luijk SJ, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Barriers and facilitators to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study. *Med Teach* in press. 2012.
34. Archer JC. State of the science in health professional education: Effective feedback. *Med Educ*. 2010;44:101-8.
35. West E, Barron DN, Dowsett J, Newton JN. Hierarchies and cliques in the social networks of health care professionals: Implications for the design of dissemination strategies. *Soc Sci & Med*. 1999;48:633-46.
36. West MA, Anderson NR. Innovation in top management teams. *J Appl Psychol*. 1996;81:680-93.
37. Jippes E, Achterkamp MC, Brand PLP, Kiewiet DJ, Pols J, van Engelen JML. Disseminating educational innovations in health care practice: Training versus social networks. *Soc Sci & Med*. 2010;70:1509-17.
38. Pendleton D, Schofield D, Tate P, Havelock P. *The new consultation: Developing doctor-patient communication*. Oxford: Oxford University Press; 2003.
39. Kratzer J, Leenders RTAJ, van Engelen JML. The social structure of leadership and creativity in engineering design teams: An empirical analysis. *J Eng & Techn Man*. 2008;25:269-86.
40. Borgatti SP, Everett MG, Freeman LC. *Ucinet 6 for windows*. Needham, MA: Analytic Technologies; 2002.
41. Ajrouch K, Blandon A, Antonucci T. Social networks among men and women: The effects of age and socioeconomic status. J Ger Ser B: *Psych Sci & Soc Sci*. 2005;60:311-7.
42. Decker D, Wheeler GE, Johnson J, Parsons RJ. Effect of organizational change on the individual employee. *T Health Care Man*. 2001;19:1-12.
43. Weick C, Martin J. Full-time and part-time independent inventors: Rising with the creative class. *Int J Entr & Inn*. 2006;7:5-12.
44. Neubert M, Taggar S. Pathways to informal leadership: The moderating role of gender on the relationship of individual differences and team member network centrality to informal leadership emergence. *Lead Q*. 2004;15:175.
45. Snijders TAB, Bosker RJ. *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London: Sage Publications Ltd; 1999.
46. Garcia-Goni M, Maroto A, Rubalcaba L. Innovation and motivation in public health professionals. *Health Pol*. 2007;84:344-58.
47. Inkpen A, Tsang E. Social capital, networks, and knowledge transfer. *Acad Man Rev*. 2005;30:146-65.



Chapter 9

General discussion

Table 12
Four specific features of PGME innovation

- The challenge of implementing the CanMEDS roles
- Regional implementation strategies and educational support
- Balance between training and patient care
- Need for regional inter-organizational networks of hospitals

The goal of this thesis was to advance the understanding of the design and implementation of competency-based PGME curricula, and to provide recommendations on the implementation processes to medical professionals and policy makers. This thesis addressed the following problem statements:

Problem statement 1: *How can we effectively and efficiently design a modernized competency-based PGME curriculum (knowledge creation)?*
Problem statement 2A): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general and more specifically…*
Problem statement 2B): *…with regard to the role of social networks in this transfer process?*

These problem statements have been operationalized into five research questions. First, we will briefly review the main findings of this thesis in relation to these research questions as stated in Table 11 (Introduction). Second, we will discuss strengths, limitations and suggestions for further research. Third, we discuss conclusions and practical implications according to the three problem statements. Finally, we discuss the scientific relevance as well as the social and practical relevance of this thesis.

Main findings

Research question 1: *How can we use systematic design methods to design a competency-based PGME curriculum?*

The research described in chapter 2 focused on how to apply systematic design methods (see Table 3 Introduction) in the development of a competency-based PGME curriculum (HORA, or Herziening Opleiding Radiologie, revision of the PGME radiology curriculum, see Table 5 Introduction). The results showed that the development process was highly dynamic and non-linear and that it was influenced by many stakeholders, developments and unforeseen factors.

Discursiveness

The design process was specified in a logical step-by-step iterative approach. The specification beforehand proved valuable because it was clear to all involved which steps needed to be taken and which results needed to be achieved before particular meetings. Strength of the discursiveness principle is that unforeseen developments can be incorporated. Especially during the curriculum approval phase, this turned out to be useful.

Hierarchical decomposition
The HORA project team broke down the overall design of the new curriculum into discrete subtasks. For the overall design, specifications were formulated, and these were discussed and agreed upon with the program directors. These steps proved useful for two reasons. First, it made the complex design task easier. Second, nvolving the program directors from the start of the process in deciding on the specifications of the new curriculum made them responsible for the ultimate results and prevented them from re-discussing the specifications and the necessity of curriculum change in a later phase.

Systematic variation
The HORA project team, the regional implementation teams, and the program directors came up with several solutions for subtasks, which allowed for an efficient division of tasks among individual members and subgroups, avoiding information overload and involving all relevant stakeholders.

Satisficing
Distinguishing short, medium and long term goals helped to focus the debate on decisions that needed to be taken at a specific moment in time. By outsourcing and decentralizing some decisions, people were able to adapt these to local circumstances, and information overload by the HORA project team was avoided.

Overall, the use of systematic design principles to structure the development process proved valuable. They led to a structured, yet flexible, development process in which creative solutions could be generated and adopters (program directors, supervisors and residents) were highly involved. This appears to be a prerequisite for successful implementation of a new curriculum.

Main findings
Research question 2: *What factors influence the implementation process of a competency-based PGME curriculum?*

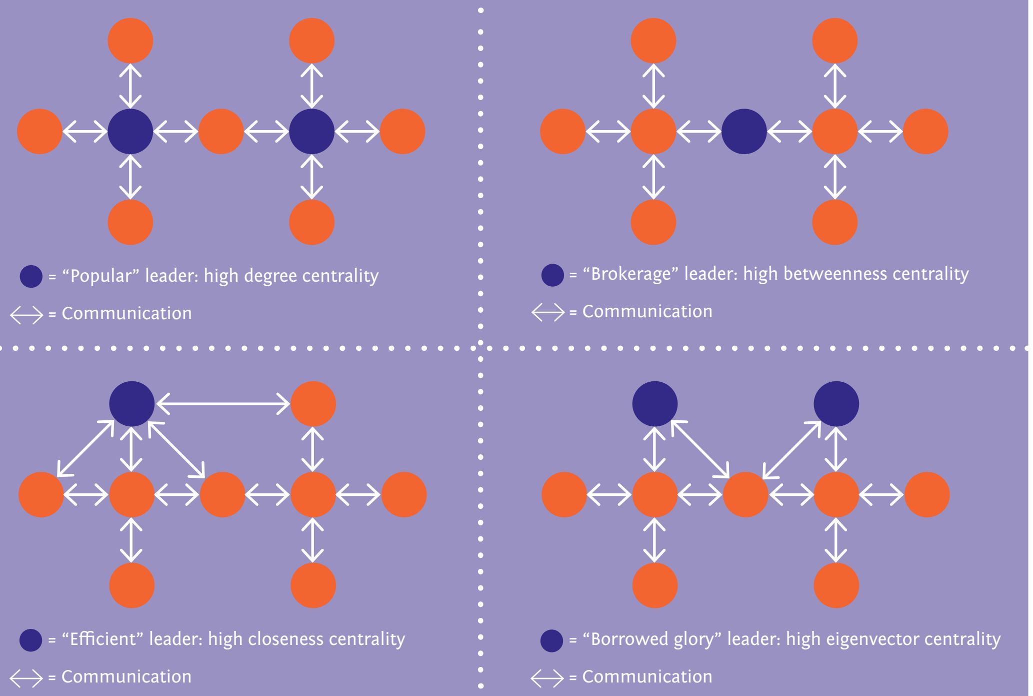
In chapter 3, we examined the promoting and impeding factors that influenced the implementation process (on national, regional and local levels) of a competency-based PGME curriculum for O&G and Pediatrics. We found three interrelated groups of factors influencing the implementation process: attributes of the innovations and adopters, attributes of the implementation process, and attributes of the organization. All factors identified in our study were to some extent promoting or impeding to the implementation process dependent on the specific circumstances and context. The factors identified in our study were comparable to those described previously[1], but in addition we observed four specific features of innovation in the context of PGME which were not documented before (see Table 12).

The challenge of implementing the CanMEDS roles
The CanMEDS roles proved difficult to operationalize (or to translate), to implement and to assess – especially the non-medical competencies like collaborator or health advocate – in workplace-based training. The innovation that had to be implemented was under construction, in fact it was a semi finished product. Furthermore, most users perceived the application in work-based training as very difficult, especially the non-medical competencies. Finally, a real sense of urgency to implement the innovations was lacking by the target audience: the program directors, supervisors and residents.

Regional implementation strategies and educational support
Our results showed that residents, supervisors, and program directors strongly appreciated the educational (and organizational) support provided, and they attached high value to regional implementation activities. The provision of both educational support and regional implementation activities at the regional and local levels, along with the customization of these activities to the specific needs of the adopters and the situation can enhance the success of the implementation process.

Balance between education and patient care
Our results indicate that successful implementation requires medical professionals to balance the importance of a given innovation

Figure 2
Centrality indices



against the constraints that it will impose on their other tasks. For example, program directors need to find a balance between personal learning objectives of the resident and patient care.

Need for regional inter-organizational networks of hospitals
Our results showed the importance of collaboration between university and general hospitals in implementing and providing PGME at various levels: between program directors within the same specialty, in providing regional educational support, and possibly with respect to managerial collaboration.

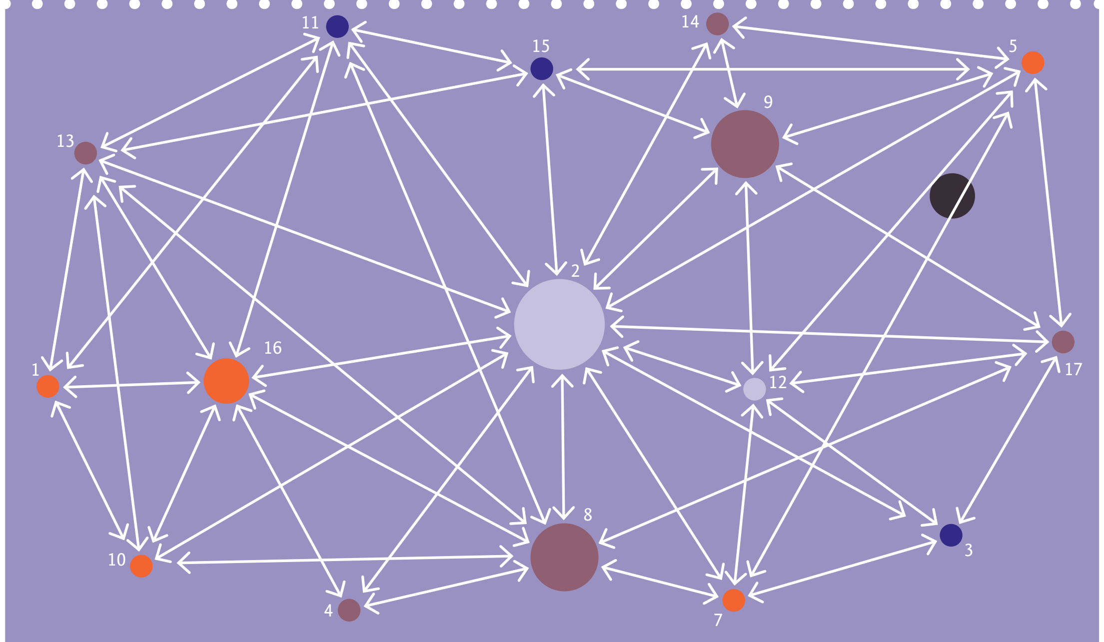
Main findings

Research question 3: *What is the influence of a diffusion approach ('let it happen'-social network density model) on PGME innovation, compared to a dissemination approach ('make it happen'-process management models)?*

In chapter 4, we compared the contributions of a diffusion approach (as measured by the density of the social network) and a dissemination approach (as measured by focused process measures taken by management) to the adoption of an innovation (novel structured feedback format to evaluate residents in training) by 356 medical specialists in 38 teams. Our dependent variable in this study concerned an attitude assessment (does the medical specialist have a positive attitude towards the innovation?) and a behavioral assessment (has the medical specialist adopted the innovation?). Our results showed that the density variables were significantly related to both the attitude assessment and the behavioral assessment. Dissemination was not significantly related to the attitude assessment, but showed a significantly relationship to the behavioral assessment.

We also found a strong interaction effect between diffusion and dissemination variables. More specifically, the relationship between diffusion (as measured by density) and innovation adoption is steeper (or stronger) under conditions of high dissemination. These results indicate the power of social networks, more specifically network density, between medical specialists for innovating PGME. Adding process measures by the management of a medical department – in most cases the program director – (e.g. setting goals, taking structured actions) can increase the adoption patterns. Possibly, the social networks between medical specialists are more used for discussing innovations, by adding process measures by management.

Figure 3
Social network data of a pediatrics department



Legend: The circles represent pediatricians. The size represents the centrality of the pediatrician in the team's social communication network. The lines represent communication about new developments on at least a monthly basis. The color shows the adoption pattern (resident assessment), red represents the first quartile, purple represents the second quartile, dark blue the third quartile and light blue the fourth quartile.

Main findings

Research question 4: *What is the influence of following an intensive Teach-the-Teacher on PGME innovation, compared to the adopter's individual network position (centrality)?*

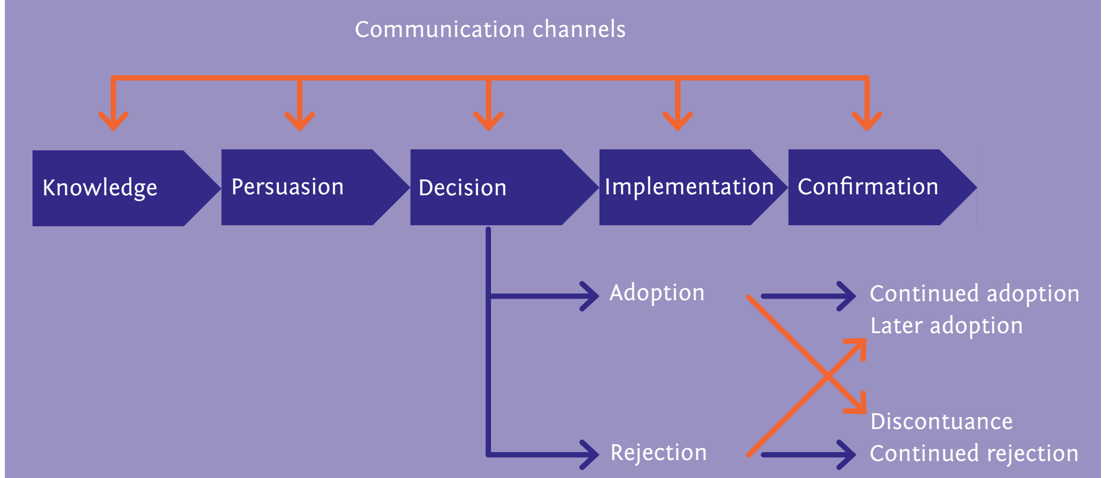
The studies described in chapter 5 and 6 compared the contributions of a Teach-the-Teacher (TtT) training and social networks to the adoption of the Pendleton rules of structured feedback, as measured by the residents' opinion of the supervising medical specialists they encountered in the six month prior to the questionnaire. The TtT course comprised 2-day training in structured and constructive feedback, use of the Mini-CEX, and adult learning principles[2]. The study as described in chapter 5 found no effect of a TtT training, but a strong effect for social networks was found, with a strong association of closeness centrality (see Figure 2) to innovation adoption, and a moderate effect of degree centrality (see Figure 2).

In chapter 6, we repeated the study described in chapter 5 with a larger sample size and we included both the residents' assessment of innovation adoption and the self-assessment of the medical specialist. Although having followed a TtT course significantly increased the medical specialist's self-assessment of the use of the novel feedback technique, it had no perceived effect on the residents' ratings of the medical specialist's innovation adoption. In contrast, the degree centrality of the medical specialist within the social network of his or her own clinical team was significantly related to innovation adoption both in the residents' assessment and in the self-assessment. Figure 3 demonstrates the principle of centrality and innovation adoption graphically in social network data of a pediatrics department.

The findings in chapter 5 and 6 state the importance of the social networks, more specifically the centrality of the medical specialist, for innovation in PGME. These social networks were more powerful than following an intensive TtT aimed at implementing the innovation. Through their position in the social network, medical specialists are able to communicate about the innovations with colleagues, discuss the benefits of the innovation and observe each other in applying the innovation[3].

Figure 4

Innovation-decision process (adapted from Rogers, 2003)



Main findings

Research question 5: *What is the influence of the leaders' network position on PGME innovation and when moderated by the social network configuration, more specifically network density and network segmentation?*

In chapter 7 we studied the contribution of clinical leader centrality (measured by four different centrality measures, see Figure 2) to the adoption of novel structured feedback by follower medical specialists. Furthermore, in chapter 8 we examined the moderating effects of two network configurations on the "clinical leader centrality / follower innovation adoption" relationship. Popular clinical leader (high in degree centrality) and efficient clinical leaders (high in closeness centrality) had significantly positive relationships with follower innovation adoption.

In addition, we found a significant positive relationship for the interaction effect of network segmentation on the leader centrality indexes of closeness; more specifically, leaders with high closeness centralities are particularly effective in highly segmented networks. We found no support for the effect of brokerage clinical leaders (high in betweenness centrality) and borrowed glory clinical leaders (high in eigenvector centrality) and the moderating effect of network density. Our findings in chapters 7 and 8 confirm our hypotheses on the importance of social networks, more specifically leader centrality and network segmentation, for the innovation of PGME. These findings may be explained by the innovation-decision process model, see Figure 4.

Popular leaders and efficient leaders have both direct ties with their followers. These direct ties may be beneficial for innovation adoption (stages decision, implementation and confirmation, see Figure 4), because they provide the necessary visibility and exposure between clinical leaders and their followers to allow for communication about the innovation, discussing the pros en cons of the innovation and to observe and discuss the desired behavior. Brokerage leaders and borrowed glory leaders have indirect ties with their followers. Possibly, these ties are important for idea penetration and gathering new information[4], both early stages of the innovation-decision process model, see Figure 4.

The positive moderating effects for network segmentation might be explained by the theory of bound normative influence[5] of Kincaid (2004). In a segmented network, direct ties exist within the subgroups and indirect ties between the subgroups. Leaders with high closeness centrality are able to grow support within a subgroup through their direct ties, and can gradually increase the boundaries of the subgroups or connect the subgroups through their indirect ties. Possibly, density influences the innovation diffusion *speed*, which might explain the absence of significant moderating relationships of network density in our study. Since we measured innovation adoption cross-sectionally we were unable to test this hypothesis.

Strengths, limitations and suggestions for further research

We will discuss the strengths, limitations and suggestions for further research for each of the three problem statements. However, first there are some overall remarks. The renewal of the competency-based PGME curricula could have been investigated from a variety of angles and disciplines with a variety of methods and techniques. As Greenhalgh et al. (2004) showed in her review, many disciplines (e.g. rural sociology, communication studies, marketing etc.) are studying innovation using different paradigms to conceptualize innovation processes and different methods and techniques. We believe that this thesis contributed meaningfully (scientifically as well as practically) to the *breadth/width of the innovation of PGME* – i.e. the design of a PGME curriculum (creation of knowledge) and the implementation of a PGME curriculum (transfer of knowledge). In addition, the thesis focused on *one specific but important factor of PGME innovation*: the role of the structural side of social networks.

Another (related) strength of this thesis is the use of both qualitative and quantitative research methods to study the research questions. The qualitative studies (chapters 2 and 3) generated enough richness in the data to look into the essentials of PGME design and implementation, while the quantitative work (chapters 4-8) allowed drawing causal inferences on the structural social network role in PGME innovation.

Furthermore, a strength of this thesis is related to the position of the PhD candidate as a researcher and as a project participant in the innovation of PGME. Because he participated in projects (HORA 1 and 2, In VIVO) at both the national, regional and local levels, he was able to see and feel the innovation processes on all these different levels. This made it easier to conduct research that produced practical valuable insights. Moreover, because he was working in the field he was able to apply the research findings immediately. Finally, the combination of researcher and project participant allowed for access to the people and processes involved in PGME, which made it possible to acquire a large and unique data set. For example, during the implementation of the radiology curriculum (the HORA 2 project) the PhD candidate administered a questionnaire to all radiology departments in the Netherlands measuring the implementation progression of the new curriculum. In the same questionnaire he also entered questions about the social networks of the radiologists.

However, doing research while working in the field may also pose risks of bias and subjectivity into the data collection and interpretation processes. We took several measures to offset these risks.

First, we chose for robust research designs for the qualitative as well as the quantitative part of the thesis. In the qualitative studies, the PhD candidate also conducted interviews in another region of the Netherland in which he was not personally involved in any projects. While the PhD candidate investigated – for example – the social networks of radiology departments, he collected network data of multiple (26) teams in which he was not personally involved to avoid bias.

Secondly, with regard to the data interpretation, all findings were critically reviewed by the entire research committee; feedback was given independently by each of the members. Furthermore, in four (out of seven) papers in this thesis, authors outside the research committee were requested to critically reflect on the findings to avoid subjectivity and bias of the committee.

In the next subsections, we will discuss the strengths (including the contribution to scientific knowledge bases), limitations and suggestions for further research according to the three problem statements.

Strengths, limitations and suggestions for further research

Problem statement 1: *How can we effectively and efficiently design a modernized competency-based PGME curriculum (knowledge creation)?*

Although several papers have described curriculum design and the evaluation of the CanMEDS framework in medical education[6-10], also in radiology[11], the design, as well as the detailed description of the development process following evidence based systematic design principles has not been documented before. This, therefore, is a major strength of our study. We showed that new knowledge about the renewed competency-based PGME curricula can be efficiently and effectively created by applying the systematic design principles. There are also some limitations. First, our study lacks empirical data on the implementation and effectiveness of the curriculum design. Further studies are therefore needed to assess the results of the new curriculum. Does it improve the quality of radiological service? What is the influence on the quantity of requests for radiological research? Does it change radiologists' job satisfaction? What is the influence on effective manpower management?

Second, the fieldwork is limited to the Netherlands. Because of differences in patient populations and the organization of radiology departments, the curriculum needs adjustment before it can be implemented in other countries.

Third, we demonstrated the methodological application of the systematic design principles in one PGME curriculum. Further research is needed to validate our findings for other PGME curricula, e.g. in surgery or internal medicine. Nevertheless, our findings are promising.

Strengths, limitations and suggestions for further research

Problem statement 2A): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general?*

The main strength of the study presented in chapter 3 is that it is one of the first to provide an in-depth empirical assessment and description of the implementation process of competency-based PGME. The theory-driven selection of respondents of various backgrounds from various layers of the project allowed a context-rich assessment and description of the complex implementation process. Although potentially very useful, such context-rich descriptions are currently lacking from the literature on healthcare innovation[1].

The main limitation of chapter 3 involves the relatively small number of interviews. For theoretical reasons, we selected two regions, each with two departments. Practical and financial constraints limited the number of interviews to 25. We cannot rule out the possibility that our results may have been different if we had sampled more regions, more departments, and more respondents, including those with other backgrounds (e.g., members of the Board of Directors or governmental policy makers). Finally, as with most qualitative research, caution is required when generalizing the findings to other countries, sectors, and types of innovations and innovation processes.

Strengths, limitations and suggestions for further research

Problem statement 2B): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) with regard to the role of social networks in this transfer process?*

The papers on the role of social networks in PGME innovation had a number of strengths. The study as described in chapter 4 is to our knowledge the first to empirically assess the effects of a combined diffusion (as measured by network density) and dissemination approach. The effect of individual network position on innovation adoption, compared to the effect of following an intensive training aimed at implementing this innovation (chapters 5 and 6), was also not documented before. The studies described in chapters 7 and 8 are again – to our knowledge – the first to empirically assess the impact of clinical leader centrality with moderating network configuration effects on follower innovation adoption.

Other strengths of the papers described in chapters 4, 6, 7, 8 include the large sample size, which made it possible to use hierarchical linear modeling. This analysis allows assessment of individual and team-level variables, and takes the nested data structure into account. Ignoring this nested data structure can result in spurious relationships and therefore incorrect conclusions. The results showed variance on both the individual and team levels, thus justifying the use of hierarchical linear modeling.

We believe we were able to gather unique network data. The medical community is difficult to penetrate, hence the few studies in the literature that were able to gather large datasets on social networks structures of medical specialists. With the papers on the role of social networks in PGME innovation we hope to advance the understanding of the (structural side of) social capital research, more specifically on the medical specialists' cognition of their wider social networks, and on the influence that the structure of these ties has on innovation adoption of their followers.

We acknowledge several limitations of the studies on the role of social networks in PGME innovation. First, they focused on innovation spreading within teams of medical specialists, regardless of whether the innovation originated from within or outside a specific team. The spreading process within teams could have been influenced by social networks that medical specialists might have had outside their own team. These could consist of medical doctors, nursing staff, management, educationalists, management consultants, other support personnel, and professional associations. It would be interesting to examine how these networks are composed and what their effects are in terms of the spreading of healthcare innovations.

Second, we measured the social network relationships for new developments in departments. To generate more richness in the nature of the social networks, further research should include different kinds of relationships (for example, collaboration, trust, and advice relationships) along with variables which can explain the social relationships found (for example, physical proximities and the personal characteristics of the respondents).

Third, we chose a cross-sectional research design. A longitudinal approach (combined with simulation methods) is needed to assess the dynamics of social networks and PGME innovation and to examine causal relationships between the structure of the social network and PGME innovation.

Fourth, while we demonstrated significant contributions of several structural social network parameters (centrality, density and segmentation) to innovation adoption, our explained variance was relatively low. This means that many other factors beyond the scope of our study influenced the adoption of our innovations studied. Further research may incorporate different structural social network parameters (for example structural equivalence, a measure into the similarity of ties) and cognitive (such as shared meaning and understanding between network actors), as well as relational dimensions (such as trust, norms, and identification) of social capital theory to explain variance in innovation adoption[12,13]. Fifth, the measurement of dissemination (chapter 4) was limited to formulating specific objectives and to structurally executing specific activities, both aimed at implementing the innovation. Other operationalizations would have been possible, and these might have yielded different results. Similarly, the lack of effect of the Teach-the-Teacher training on the implementation of structured feedback should be interpreted with caution. Earlier studies with an experimental design did show long-lasting effects of Teach-the-Teacher courses on course participants' educational behavior[14]. From a theoretical perspective, it may be more appropriate to measure the effectiveness of the Teach-the-Teacher training with multiple criteria (e.g., Kirkpatrick's criteria of reaction, learning, behavior and results[15]).

Sixth, our study was limited to innovation in medical education. Although training of residents and healthcare delivery are integrated in clinical practice in the Netherlands, and the new structured feedback technique can have a direct impact on healthcare delivery, clinical errors, and patient safety, we need to be cautious in generalizing the findings from this study to innovation in healthcare in general. The same holds true for the results of the study in chapters 7 and 8. In contrast to most businesses, the relationship between medical specialists and their clinical leader appears to be more collegial than hierarchical. Because our study sample was limited to the healthcare sector, caution is needed in generalizing our findings to other sectors, especially non-professional organizations.

Finally, the dependent variable in all social networks papers was the adoption of the educational innovation "structured and constructive" feedback. We chose to include the same dependent variable in all analyses to allow comparisons between papers. Although this educational innovation is perceived as one of the most important innovations embedded in the renewal of PGME as we demonstrated in chapter 3, the implementation of the new competency-based curricula includes more than just this particular innovation. Further research on social networks and PGME innovation should include other educational innovations which are part of the implementation

Table 13
Recommendations for design processes in PGME

- Specify the design process beforehand in several steps
- Accept and use the discursive nature of complex design processes to improve the design
- Break the overall design problem down into several interdependent subtasks, according to the different components of the curriculum (for example specialty profile, themes / building blocks curriculum, and assessment strategy and instruments) – but ensure the relation between the subtasks
- Formulate design specifications for the overall design (for example; the curriculum needs to be competency-based or the curriculum needs to encompass training periods in university and general hospitals)
- Involve professionals (program directors, supervisors and residents) in the design process
- Use all brainpower available (from program directors, supervisors, and residents) to formulate solutions for each subtask; search for acceptable solutions with regard to the design specifications instead of searching for optimal solutions
- Make a distinction between short, medium and long term decisions
- Organize organizational and educational support to the design team

Table 14
Recommendations for implementation processes in PGME

- Create a coordination structure of the implementation process (by specialty)
- Translate the national curriculum to a regional and local curriculum that specifies the CanMEDS roles, procedures for work-based learning, and assessment in the context of patient
- Balance “letting it emerge” and “making it happen,” depending on implementation progression
- Establish goals, a timeframe, and monitor the results in concordance with the professional
- Facilitate knowledge sharing through meetings and social networks
- Identify and reward good leaders and good teams; ensure continuity
- Use residents as change agents
- Build strong regional collaboration networks between university and general hospitals
- Use training as an implementation tool (to raise awareness among users and to learn the required skills and knowledge)
- Organize logistic, organizational and educational support
- Achieve a careful balance between education (work-based learning) and patient care

of competency-based PGME, as described in chapter 3. Moreover, the impact of the structure of the social network may depend on the context studied, as we demonstrated in the conceptual development of our hypotheses. Further research might incorporate different phases of the innovation-decision process, adoption as well the phases prior to adoption. It would also be fruitful to examine what effects the structure of the social network has on different outcomes, such as performance and innovation adoption, alongside with variables which might explain why some relationships were found.

Despite these limitations, we believe that the social network papers in this manuscript contribute significantly to the knowledge bases in the field of innovation, leadership, training, medical education and social networks.

Conclusions and practical implications
In the next subsections we discuss conclusions and practical implications according to the three problem statements.

Problem statement 1: *How can we effectively and efficiently design a modernized competency-based PGME curriculum (knowledge creation)?*

The use of the systematic design principles proved useful and applicable in the development process of new postgraduate medical curricula. Our description of the design, design process, and content of the new curriculum can be useful for medical scientific societies and program directors designing new curricula. Based on our experience, a number of recommendations can be generated for future design processes of PGME curricula (see Table 13).

Conclusions and practical implications
Problem statement 2A): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general?*

We showed that the PGME innovation process is highly dynamic, non-linear and influenced by many factors. Based on our experience, a number of recommendations can be generated for future PGME implementation processes, see Table 14.

Table 15

Recommendations for using social networks effectively in PGME innovation

- Be aware of the potential power of the structure of social networks in innovation processes
- Identify the social network structures (e.g. by using social network analysis), organize organizational / educational support if needed
- Identify *medical specialists* who are central in terms of degree and closeness centrality (e.g. by using social network analysis), and incorporate them in change initiatives, let them help to overcome resistance among their colleagues, and let them follow training and education aimed at implementing innovations
- *Clinical leaders* need to attain high central network positions according to degree and closeness centrality. Possible social network measures that a leader can take to increase his centrality include: Being more present at team meetings, increasing the frequency of team meetings, increasing the frequency of bilateral meetings with team members
- Direct the structure of the social network of the medical specialist team towards rather dense (but not too dense) communication. Use the subgroups in a department to diffuse information about innovations. Possible social network measures that clinical leaders can take to change the structure of the social network in the team include: Adding or removing team members, introducing job rotation schemes, and altering the frequency of team meetings
- Add additional process measures to increase the natural diffusion rate and level of adoption (caused by the social network structures). Possible process measures would include project management tools, inviting experts, and organizing peer supervision meetings to share knowledge and evaluate individual and team performance

Conclusions and practical implications

Problem statement 2B): *How can we improve the knowledge transfer (diffusion, dissemination, implementation) with regard to the role of social networks in this transfer process?*

We showed that the structure of the social networks is important in the diffusion processes of PGME innovation. Chapters 5 and 6 demonstrated that the individual network position of medical specialists according to degree and closeness centrality was associated with high adoption patterns of the educational innovation "competency-based structured feedback". The network position of the clinical leaders (program directors) was significantly related to follower innovation adoption, as demonstrated in chapter 7. In addition to the individual network position, the structure of the social network as a whole also influenced innovation adoption patterns. Network density was associated (in an inverse U-shaped relationship) with innovation adoption (chapter 4), and network segmentation positively moderated the relationships between leader closeness centrality and follower innovation adoption (chapter 8).

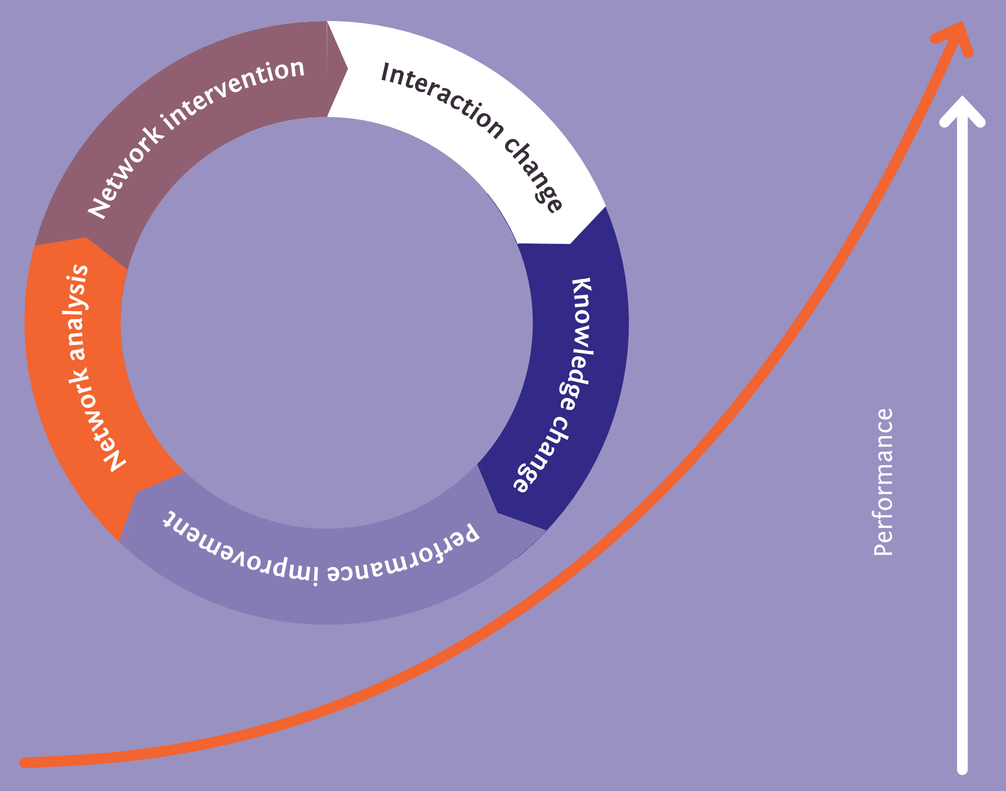
Based on our experience, a number of recommendations can be proposed for using social networks effectively in PGME innovation processes, see Table 15.

Scientific relevance of the thesis

The scientific relevance of this thesis is as follows. First, by applying the systematic design principles to the PGME curriculum of radiology (HORA 1, see Table 5 Introduction), we validated the design principles in the context of PGME curricula and we extended the literature on curriculum development. More specifically, the design principles (see Table 3, Introduction) hierarchical decomposition, discursiveness, systematic variation and satisficing proved useful extensions on this literature, see Main Findings, Research Question 1 of this General discussion.

Second, our context-rich description of the implementation process of the curricula Pediatrics and O&G (In VIVO, see Table 6) added to new research directions that value these rich descriptions. We confirmed earlier research into complex innovation in healthcare and described four unique features of PGME innovation (see Table 12).

Figure 5
The Continuous Network Improvement Model



Third, we advanced the understanding of social networks in PGME innovation. We demonstrated the importance of centrality, density and segmentation in PGME innovation. By building and testing hypotheses on different centrality indexes and network configurations (density and segmentation) we advanced the structural side of social network research. Furthermore, we added to the knowledge base of product innovation by demonstrating the importance of combining a dissemination approach with the natural process of diffusion. Finally, we advance the knowledge base of leadership research; more specifically, the cognition of leaders of their wider social networks and the impact the actual structure of leaders' ties with team members has, on follower innovation adoption. We demonstrated the importance of the joint incorporation of leader centrality and the configuration of the network, the leader is supposed to lead.

Fourth, we were able to gather a large data set of 38 teams, 370 medical specialists and 357 residents. The acquisition of such a large network data set in a difficult to penetrate – and therefore less researched – community is a unique feature of our research. Furthermore, the combination of network data and hierarchical linear modeling is a major strength and has – to our knowledge – not been published before. Our dataset and analyses techniques allowed us to build a strong case regarding the knowledge about the role of social networks in innovation adoption in healthcare.

Finally, the combination of design methods and empirical methods in one thesis can be considered a unique feature of this research. Since the founding of the management and organization faculty in Groningen in 1983 there is an ongoing debate whether or not the essence of the research and education of the faculty should be in the design methods or in the empirical methods[16]. This thesis demonstrated that both can be valuable; empirical methods to find the relationships that actually exist between certain concept (such as social networks and innovation adoption) and design methods to effectively and efficiently design the intervention that will provide the requested changes (such as designing an information-rich, innovative and effective network).

Social and practical relevance of the thesis

Our thesis can be viewed as a demonstration of the power of social networks in PGME innovation. Social networks between medical specialists functioned as conduits for transferring knowledge about the innovations, for discussing the benefits of the innovation and to demonstrate the desired behavior to each other. The embeddedness of clinical leaders (program directors) in their social networks, as well as the characteristics of the medical team's social network, are both predictors of innovation adoption. Social networks proved to be as least as important as more conventional ways of conveying knowledge, such as training and education and top-down implementation plans. This confirms the importance of social networks for physicians in acquiring knowledge and staying up-to-date. This thesis may create the awareness among physicians that social networks can be used to achieve certain ends. In order to so, the thesis provides medical specialists, as well as their clinical leaders, with recommendations how to change their social networks in order to reach higher innovation adoption patterns.

Figure 5 demonstrates the potential principles of continuous network improvement graphically. We demonstrated this model for one particular performance outcome – innovation adoption – but it is likely that other performance outcomes (such as productivity) will be equally affected by the power of social networks. Network interventions will lead to more interpersonal and social interactions, this will engage knowledge creation and exchange, leading towards performance improvement, which will lead to network analysis etc.

Besides the practical relevance of the social network part of this thesis, the thesis also provides policymakers, program directors, supervising medical specialists and residents, with recommendations how to generally design ánd implement the innovations embedded in the renewed competency-based PGME curriculum. We hope that these recommendations are useful for all stakeholders active in the field of PGME innovation, to more efficiently and effectively create and transfer knowledge about the innovations in the complex and fascinating field of medical education in healthcare.

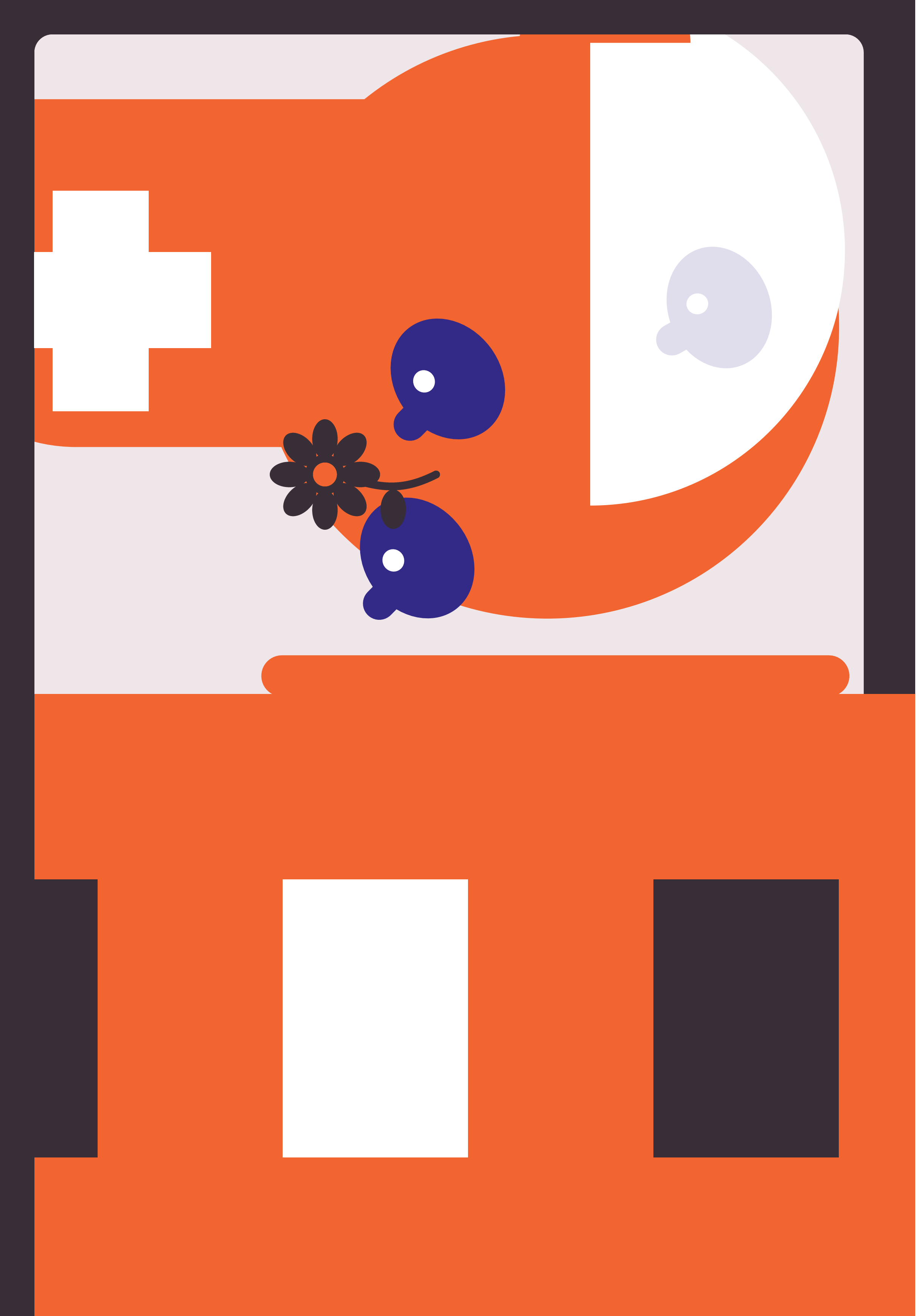
We conclude with a quote that underlines the power of social networks and social networking in current and future innovation processes.

"Peer production is about more than sitting down and having a nice conversation. It's about harnessing a new mode of production to take innovation and wealth creation to new levels".

Eric Schmidt (CEO Google, 2007)

References

1. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Q.* 2004;82:581-629.
2. Mann KV. Theoretical perspectives in medical education: Past experience and future possibilities. *Med Educ*. 2011;45:60-8.
3. Rogers EM. *Diffusion of innovations*. New York: Free Press; 2003.
4. Kratzer J, Hölzle K, Gemünden HG. How the network position of R&D team managers and members affects their evaluations of creative performance. *Creat & Inn Man*. 2010;19:107-18.
5. Kincaid DL. From innovation to social norm: Bounded normative influence. *J Health Comm*. 2004;9:37-57.
6. Chou S, Cole G, McLaughlin K, Lochyer J. CanMEDS evaluation in Canadian postgraduate training programmes: Tools used and programme director satisfaction. *Med Educ.* 2008;42:879-86.
7. Mickelson JJ, Macneily AE. Translational education: Tools for implementing the CanMEDS competencies in Canadian urology residency training. *Can Urol Ass J*. 2008;2:395-404.
8. Frank J, Danoff D. The CanMEDS initiative: Implementing an outcomes-based framework of physician competencies. *Med Teach.* 2007;29:642-7.
9. Freiman A, Natsheh A, Barankin B, Shear N. Dermatology postgraduate training in Canada: CanMEDS competencies. *Dermatol Online J*. 2006;12:6-.
10. Ringsted C, Hansen T, Davis D, Scherpbier A. Are some of the challenging aspects of the CanMEDS roles valid outside Canada? *Med Educ.* 2006;40:807-15.
11. Baerlocher M, Asch M. The interventional radiologist as "clinician": What does it mean? CanMEDS for the interventional radiologist. *Can Assoc Radiol J*. 2006;57:25-9.
12. Inkpen A, Tsang E. Social capital, networks, and knowledge transfer. *Acad Man Rev.* 2005;30:146-65.
13. Nahapiet J, Ghoshal S. Social capital, intellectual capital, and the organizational advantage. *Acad Man Rev*. 1998;23:242-66.
14. Rubak S, Mortensen L, Ringsted C, Malling B. A controlled study of the short- and long-term effects of a train the trainers course. *Med Educ.* 2008;42:693-702.
15. Kirkpatrick D, Kirkpatrick J. Prepare for evaluation. *Lead Exc.* 2006;23:13.
16. Van Engelen JML. In het bijzonder bedrijfskunde: *De integrerende rol van de technologie en de ontwerpbenadering; inaugurele rede bedrijfskunde Rijksuniversiteit Groningen*. Alpen aan den Rijn: Samson; 1992.



Summary

Samenvatting

Summary

Chapter 1 Introduction. This thesis addressed how to effectively and efficiently design a modernized competency-based PGME curriculum and how to improve the knowledge transfer (diffusion, dissemination, implementation) about the renewed competency-based PGME curricula in general and more specifically with regard to the role of social networks in this transfer process.

Chapter 2 focused on how to apply systematic design methods in the development of a competency-based PGME curriculum in radiology. The results showed that the development process was highly dynamic and non-linear and that it was influenced by many stakeholders, developments and unforeseen factors. Overall, the use of systematic design principles to structure the development process proved valuable. They led to a structured, yet flexible, development process in which creative solutions could be generated and adopters (program directors, supervisors and residents) were highly involved. This appears to be a prerequisite for successful implementation of a new curriculum.

In **chapter 3**, we examined the promoting and impeding factors that influenced the implementation process of a competency-based PGME curriculum for O&G and Pediatrics. We found three interrelated groups of factors influencing the implementation process: attributes of the innovations and adopters, attributes of the implementation process, and attributes of the organization. All factors identified in our study were to some extent promoting or impeding to the implementation process depending on the specific circumstances and context. The factors identified in our study were comparable to those described previously, but in addition we observed four specific features of innovation in the context of PGME which were not documented before: the challenge of implementing the CanMEDS roles, regional implementation strategies and educational support, balance between education and patient care and need for regional inter-organizational networks of hospitals.

In **chapter 4**, we compared the contributions of a diffusion approach (as measured by the density of the social network) and a dissemination approach (as measured by focused process measures taken by management) to the adoption of an innovation (novel structured feedback format to evaluate residents in training). Our results showed that the density variables were significantly related to both the attitude assessment (does the medical specialist have a positive attitude towards the innovation?) and the behavioral assessment (has the medical specialist adopted the innovation?). Dissemination was not significantly related to the attitude assessment, but showed a significantly relationship to the behavioral assessment. We also found a strong interaction effect between diffusion and dissemination variables. More specifically, the relationship between diffusion and innovation adoption is steeper (or stronger) under conditions of high dissemination. Adding process measures by the management of a medical department – in most cases the program director – (e.g. setting goals, taking structured actions) can increase the adoption patterns.

The studies described in **chapter 5 and 6** compared the contributions of a Teach-the-Teacher (TtT) training and social networks to the adoption of the Pendleton rules of structured feedback. The TtT course comprised 2-day training in structured and constructive feedback, use of the Mini-CEX, and adult learning principles. The study as described in chapter 5 found no effect of a TtT training, but a strong effect for social networks was found, with a strong association of closeness centrality to innovation adoption, and a moderate effect of degree centrality.

In **chapter 6**, we repeated the study described in **chapter 5** with a larger sample size and we included both the residents' assessment of innovation adoption and the self-assessment of the medical specialist. Although having followed a TtT course significantly increased the medical specialist's self-assessment of the use of the novel feedback technique, it had no perceived effect on the residents' ratings of the medical specialist's innovation adoption. In contrast, the degree centrality of the medical specialist within the social network of his or her own clinical team was significantly related to innovation adoption both in the residents' assessment and in the self-assessment.

In **chapter 7**, we studied the contribution of clinical leader centrality (measured by four different centrality measures) to the adoption of novel structured feedback. Furthermore, in chapter 8 we examined the moderating effects of two network configurations on the "clinical leader centrality / follower innovation adoption" relationship.
Popular clinical leader (high in degree centrality) and efficient clinical leaders (high in closeness centrality) had significantly positive

relationships with follower innovation adoption. We found a significant positive relationship for the interaction effect of network segmentation on the leader centrality index of closeness; more specifically, leaders with high closeness centralities are particularly effective in highly segmented networks. We found no support for the effect of brokerage clinical leaders (high in betweenness centrality) and borrowed glory clinical leaders (high in eigenvector centrality) and the moderating effect of network density.

Chapter 9 General discussion. We validated the design principles in the context of PGME curricula and we extended the literature on curriculum development. Our context-rich description of the implementation process of the curricula pediatrics and O&G added to new research directions that value these rich descriptions. We advanced the understanding of the structure of social networks in PGME innovation; we demonstrated the importance of centrality, density and segmentation. Furthermore, we added to the knowledge base of product innovation by demonstrating the importance of combining a dissemination approach with the natural process of diffusion and we advance the knowledge base of leadership research. Our large dataset and advanced analyses techniques allowed us to build a strong case regarding the knowledge about the role of social networks in innovation adoption in healthcare. This thesis may create the awareness among physicians that social networks can be used to achieve certain ends. The thesis provides policymakers, program directors, supervising medical specialists and residents, with recommendations how to generally design ánd implement the innovations embedded in the renewed competency-based PGME curriculum.

Samenvatting

Hoofdstuk 1 Introductie. Dit proefschrift verschaft inzicht in hoe effectief en efficiënt een gemoderniseerd competentiegericht curriculum voor de medisch specialistische vervolgopleidingen te ontwerpen en hoe deze te implementeren. Hierbij is specifiek gekeken naar de rol van sociale netwerken in dit implementatie-proces.

Hoofdstuk 2 richt zich op de toepassing van de systematische ontwerpprincipes in de ontwikkeling van een competentiegericht curriculum voor de medisch specialistische vervolgopleiding radiologie. De resultaten tonen aan dat het ontwikkelingsproces zeer dynamisch en niet-lineair van aard is. Het proces wordt beïnvloed door veel belanghebbenden, ontwikkelingen en onvoorziene factoren. Het gebruik van systematische ontwerpprincipes in het ontwikkelingsproces blijkt waardevol. Deze leiden tot een gestructureerd, maar flexibel ontwikkelingsproces waarin creatieve oplossingen worden gegenereerd en adopteerders (opleiders, opleidingsgroepen en arts-assistenten) zelf zijn betrokken.

In **hoofdstuk 3** onderzoeken we de bevorderende en belemmerende factoren voor het implementatieproces van een competentiegericht curriculum voor de medisch specialistische vervolgopleidingen obstetrie & gynaecologie en kindergeneeskunde. We vonden drie onderling samenhangende groepen van factoren: eigenschappen van de innovatie en adopteerders, kenmerken van het implementatie-proces, en kenmerken van de organisatie. Alle factoren die in onze studie naar voren komen zijn tot op zekere hoogte bevorderend of belemmerend, dit is afhankelijk van de specifieke omstandigheden en context. De factoren die in onze studie naar voren komen zijn vergelijkbaar met eerder beschreven factoren. Echter, deze studie laat vier specifieke kenmerken van de innovatie in de context van de medisch specialistische vervolgopleidingen zien: (1) de uitdaging van de invoering van de CanMEDS competenties, (2) de regionale implementatiestrategieën en onderwijskundige ondersteuning, (3) de balans tussen opleiding en patiëntenzorg, en (4) de noodzaak van regionale netwerken tussen ziekenhuizen.

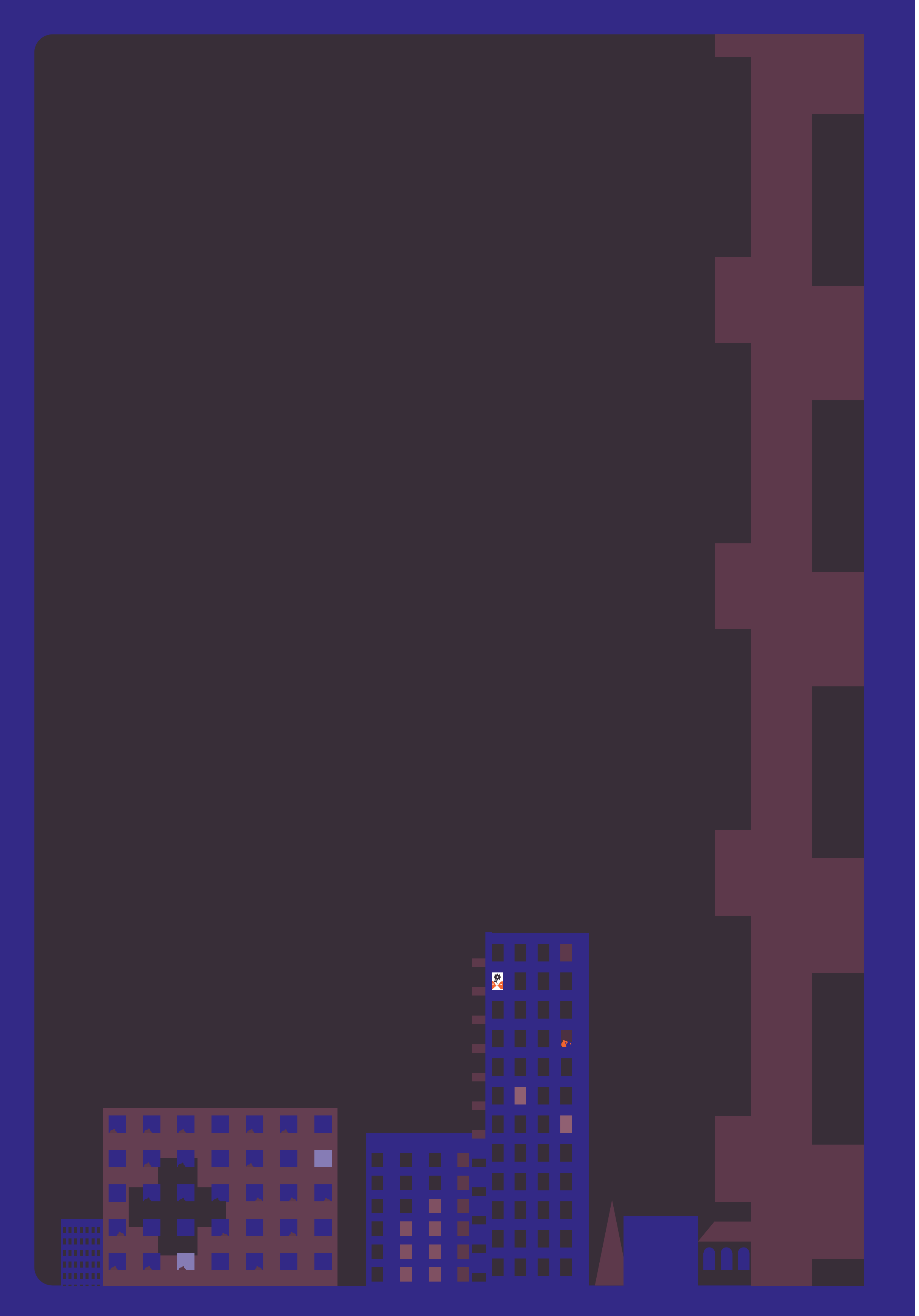
In **hoofdstuk 4** vergelijken we de bijdrage van een diffusieaanpak (gemeten door de dichtheid van het sociale netwerk) en een disseminatieaanpak (gemeten door procesmaatregelen genomen door het management) op de invoering van een innovatie (nieuwe gestructureerde en constructieve feedback). Onze resultaten tonen aan dat de diffusieaanpak significant is gerelateerd aan zowel de attitude beoordeling (heeft de medisch specialist een positieve houding ten aanzien van de innovatie?) als de gedragsmatige beoordeling (voert de medisch specialist de innovatie correct uit?). De disseminatieaanpak daarentegen is niet significant gerelateerd aan de attitude beoordeling, maar toont wel een significant relatie met de gedragsbeoordeling. Ook laat de studie een sterk interactie-effect zien tussen de diffusieaanpak en disseminatieaanpak. Meer specifiek, de relatie tussen de diffusieaanpak en innovatieadoptie is steiler (of sterker) bij veel procesmaatregelen (disseminatieaanpak). Het toevoegen van procesmaatregelen (bijv. het stellen van doelen, het nemen van gestructureerde acties) door het management van een medische afdeling – in de meeste gevallen de opleider – bevordert de adoptie.

De studies in **hoofdstuk 5 en 6** vergelijken de invloed van zowel het volgen van een Teach-the-Teacher (TtT) training door de medisch specialist, als zijn/haar positie in het sociale netwerk op de adoptie van de innovatie "gestructureerde en constructieve feedback". De TtT training bestaat uit een 2-daagse training in gestructureerde en constructieve feedback, het gebruik van de korte praktijk beoordeling, en de grondslagen voor het leren van volwassenen. De studie laat geen effect zien van een TtT training op innovatieadoptie, maar er blijkt wel een sterk effect te zijn van de netwerkpositie van de medisch specialist.

In **hoofdstuk 6**, herhalen we de studie – zoals beschreven in **hoofdstuk 5** – met een grotere steekproef, en we includeerden zowel de beoordeling van innovatieadoptie door de supervisoren zelf, als die van de arts-assistenten in de analyse. Het blijkt dat het volgen van een TtT training door supervisoren significant gerelateerd is aan hun zelf-evaluatie van het gebruik van de nieuwe feedback techniek, maar het volgen van de training heeft geen waargenomen effect op de perceptie van de arts-assistenten met betrekking tot de innovatie-adoptie van de medisch specialist. Daarentegen bleek uit de studie dat de netwerkpositie van de medisch specialist binnen het sociale netwerk van zijn of haar eigen team, wel significant gerelateerd is aan beide beoordelingen (zelf-beoordeling en arts-assistenten beoordeling).

In **hoofdstuk 7** bestuderen we het effect van de netwerkpositie van de klinische leider (gemeten door vier verschillende centraliteiten) op de innovatieadoptie van de medisch specialisten in het team. In **hoofdstuk 8** onderzoeken we tevens de modererende effecten van twee netwerkconfiguraties op de relatie tussen de netwerk-positie van de klinische leider en de innovatieadoptie van zijn/haar volgers. Populaire klinische leiders (hoog in degree centraliteit) en efficiënte klinische leiders (hoog in closeness centraliteit) blijken teams te leiden van medisch specialisten met significant hogere innovatie-adoptie. Ook laat de studie een significant positief verband zien voor het interactie-effect van netwerksegmentatie: meer specifiek, klinisch leiders met een centrale netwerkpositie zijn bijzonder effectief in sterk gesegmenteerde netwerken. We vonden niet de verwachte verbanden voor het effect van brokerage klinische leiders (hoog in betweenness centraliteit) en borrowed glory klinische leiders (hoog in eigenvector centraliteit). Tevens toont de studie geen bewijs voor het modererende effect van netwerkdichtheid.

Hoofdstuk 9 Discussie. De systematische ontwerpprincipes blijken toepasbaar voor het ontwerpen van een competentiegericht curriculum voor de medisch specialistische vervolgopleidingen. Hiermee hebben we de literatuur over de ontwikkeling van dergelijke curricula uitgebreid. Onze contextrijke beschrijving van het implementatieproces van de curricula kindergeneeskunde en obstetrie & gynaecologie leveren bruikbare aanwijzingen op over de aanpak van dergelijke complexe veranderprocessen. Verder hebben we de literatuur over de structurale kant van sociale netwerken uitgebreid met kennis over het belang van centraliteit, dichtheid en segmentatie. Ook laten we zien dat het van belang is om proces-maatregelen toe te voegen aan het natuurlijke proces van diffusie door sociale netwerken. Onze grote dataset en geavanceerde analysetechnieken maakten het mogelijk om deze verbanden te ontdekken. Dit proefschrift kan leiden tot de bewustwording onder artsen dat sociale netwerken kunnen worden gebruikt om bepaalde doelen te bereiken. Het proefschrift biedt beleidsmakers, opleiders, supervisoren en arts-assistenten aanbevelingen hoe ze competentiegericht curricula voor de medisch specialistische vervolgopleidingen kunnen ontwerpen én implementeren.



About the author

Erik Jippes was born on September 1, 1981 in Beilen, The Netherlands. In 1999, he passed his final exams Atheneum at the Dr. Nassau College in Assen and in the same year he started his study Management & Organization at the University of Groningen.
His fascination with innovation processes started with his job during his study in a petrol station, in which he helped the owner in designing and implementating a new organizational model. During his study he professionalized the sponsor committee at the Groninger Studenten Volleybal Vereniging Veracles and developed models for better acquisition. Logically, his masters was in business development, that means the simultaneous development of products, markets and organizations. He applied his knowledge in his master thesis to the surgery department at the UMCG in which he investigated the organizational feasibility of a new educational model constituting of a fusion between skills training and conducting surgical procedures.
In 2004 he finished his masters thesis and in the same year he started working at the Wenckebach Institiute at the UMCG as educational concultant, specialized in change management and innovation. Several large design and implementation projects followed, of which the most significant ones were the design and nationwide implementation of the renewed competency-based curriculum of radiology, and the regional implementation of the curricula of peadiatrics and obstetrics & gynaecology. However, in 2010 he made a move back to his roots of business development and became manager of the Center for Medical Imaging North East Netherlands, a research consortium of the UMCG, University of Twente, Siemens and around forty SME's in the Netherlands.
The mission of CMI is to conduct groundbreaking research into minimally to non-invasive medical imaging technology, together with researchers and business partners.

Author's publications

2012 Jippes E, Pols J, Achterkamp MC, Pols J, van Engelen JML, Brand PLP. Impact of clinical director centrality and network configuration on follower innovation adoption *(submitted)*

2012 Jippes E, Pols J, Achterkamp MC, Pols J, M.C. Leliveld, Brand PLP, van Engelen JML. The impact of clinical leader centrality on follower innovation adoption *(submitted)*

2012 Jippes E, Achterkamp MC, Pols J, Brand PLP, van Engelen JML. Diffusing (let it happen) or disseminating (make it happen) innovations in health care? *(submitted)*

2012 Jippes E, Steinert, Y, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Applying social network analysis to explain clinical teaching behavior: exploratory study *(submitted)*

2012 Jippes E, Luijk SJ, Pols J, Achterkamp MC, van Engelen JML, Brand PLP. Facilitators and barriers to a nationwide implementation of competency-based postgraduate medical curricula: A qualitative study, Medical Teacher, in press 2012

2010 Jippes E, Gratama JWC. Oudkerk M. Concilium Radiologicum – HORA 2 commissie, Memorad 2010; 15(4): 7-9

2010 Jippes E, Achterkamp, MC, Pols J, Brand, PLP, van Engelen JML. Disseminating educational innovations in health care: Training versus social networks?, Socal Science & Medicine 2010; 70(2010): 1509–1517

2010 Jippes E, van Engelen JML, Brand, PLP, Oudkerk M. Competency based (CanMEDS) residency training program in radiology: systematic design procedure, curriculum and success factors, European Radiology 2010; 20: 967–977

2009 Jippes E, Lonkhuijzen LRCW, Boendermaker PM, Loon AJ, Mourits MJE. Een spagaat met voordelen, Medisch Contact 2009; 64(9): 385-387

2009 Koops A, Eising HP, Franssen MTM, Jippes E, Mourits MJE, van Lonkhuijzen LCRW. De jaarlijkse kwaliteitsevaluatie van de opleiding tot gynaecoloog in de Onderwijs- en OpleidingsRegio Noord-Oost, TMO 2009; 28(1): 29-35

2008 Baane JA, Heineman MJ, Busari JO, Fluit CRMG, Jippes E, de Kroon C. Aios vaardig aan het roer, TMO 2008; 27(6): 296-303

2008 Jippes E, Hercules LM, Duiverman EJ, Verhagen AEE, Mourits MJE. Aanpak invoering vernieuwingen specialistenopeiding Kindergeneeskunde en Obstetrie & Gynaecologie in de OOR Noord- en Oost-Nederland, TMO 2008; 27(4): 181-190

2008 Jippes E, Meininger AK, Oudkerk M. Op weg naar één curriculum en acht opleidingen radiologie, Memorad 2008; 13(2): 5-7

2007 Pols J, Jippes E, Verhagen AEE, Hercules LM, Sauer PJJ. Vernieuwing opleiding kindergeneeskunde in het Beatrix Kinderziekenhuis, Universitair Medisch Centrum Groningen: Ontwerp. TMO 2007; 26(2): 63-74

2004 Jippes E. Intensivering vaardigheidsonderwijs opleiding chiurgie, een studie naar de organisatorische haalbaarheid in de OOR N-O-Nederland, Faculteit Bedrijfskunde: Groningen, 2004

Papers/posters:

2008 Jippes E, Pols J, Achterkamp MC, Kiewiet DJ, van Engelen JML, Brand PLP. Evaluatie opleidingsvernieuwingen vervolgopleiding, paper NVMO congress 2008

2008 Oudkerk M, Jippes E. How to manage imaging education: Reform of Dutch radiology postgraduate training and education, paper MIR congress 2008

2008 Meininger AK, Hercules LM, Jippes E, Verhagen AAE, Duiverman EJ, Mourits MJE. Regional meetings: A powerful way to support educational innovations, poster AMEE congress 2008

2008 Croon, C de, Vreede, I de, Bavel, J van, Cate, F ten, Jippes E, Busari J. Implementations of competency-oriented PGME-programs necessitate professionalisation of the residents: The Dutch experience, paper AMEE congress 2008

2007 Jippes E, Eising HP, Remmelts P, Mourits MJE. Naar kwaliteitssystemen in de medische vervolgopleidingen, paper NVMO congress 2007 (selected best paper)

2007 Hercules LM, Jippes E, Verhagen AEE, Meininger AK, Duiverman EJ, Mourits MJE. Opleidingsvernieuwingen in relatie tot veranderkundige en onderwijskundige inzichten, paper NVMO congress 2007

2007 Jippes E, Remmelts P, Eising HP, Mourits MJE. Towards quality monitoring systems in postgraduate medical education, poster AMEE congress 2007

2006 Jippes E, Achterkamp MC, Kiewiet DJ, van Engelen JML. Invoeren van onderwijsvernieuwingen op de werkvloer door beïnvloeding van communicatiestromen, poster NVMO congress 2006

2006 Jippes E, Achterkamp, MC, Kiewiet, DJ, van Engelen JML. Effective curriculum innovation through managing of communication patterns, Poster AMEE congress 2006

Dankwoord

In mei 2005 ben ik met mijn onderzoek begonnen en ik rond het nu – in mei 2012 – af. Het bleek voor mij een goede keus. Tijdens mijn onderzoek leerde ik de boeiende wereld van de zorg kennen met haar vele stakeholders, vele aandachtsgebieden en hoog politieke omgeving. Dit intrigeerde mij en tot op de dag van vandaag blijft het ziekenhuis op mij als bedrijfskundige een sterke aantrekkingskracht uitoefenen. Destijds leek het ziekenhuis mij een organisatie waar ik als pas afgestudeerde bedrijfskundige veel zou kunnen leren en veel ontplooiingsmogelijkheden zou kunnen krijgen. Deze verwachting is volledig ingelost wat ik in het volgende zal toelichten.

In 2005 heb ik met het management van het Wenckebach Instituut de afspraak gemaakt dat ik twee dagen per week onderzoek zou doen en de overige tijd ingezet zou worden op adviesprojecten in met name de medisch specialistische vervolgopleidingen. Daarbij zou ik mijn onderzoeksactiviteiten richten op hetgeen ik tegen zou komen in de adviesprojecten. Om ervoor te zorgen dat de resultaten meteen ter beschikking zouden komen voor de doelgroep en niet pas bij oplevering van het proefschrift, heb ik ervoor gekozen om te promoveren op artikelen. Deze afspraken hadden een aantal voordelen. Ten eerste leerde ik veel en ten tweede vergrootte ik hiermee mijn eigen netwerk in het ziekenhuis. Ook zat ik "in" mijn onderzoekswereld, wat vele voordelen heeft omdat je het effect van je interventies direct ziet en je de complexiteit leert begrijpen.

De adviesprojecten die voor mijn onderzoek relevant waren zijn In VIVO (2006-2010), het HORA 1 project (2006-2008) en het HORA 2 project (2009-2011). Voor een uitgebreide omschrijving van deze projecten verwijs ik naar de inleiding van dit proefschrift. In het In VIVO project leerde ik interessante artsen kennen. In het bijzonder wil ik Marian Mourits en Eduard Verhagen bedanken voor hun passie en leiderschap in het project en de natuurlijkheid waarmee zij mijn competenties inpasten in hun eigen werkzaamheden. Maar ook de opleiders, supervisoren en arts-assistenten waarmee ik op een plezierige manier heb gewerkt, ben ik erkentelijk.

De HORA 1 en 2 projecten waren landelijke projecten wat een hele serie extra communicatieschijven met zich meebracht.
Een uitermate interessant proces waarin ik erg plezierig heb samengewerkt met alle betrokken radiologen en arts-assistenten.

Ik wil hier graag twee heren noemen, Matthijs Oudkerk en Michiel de Haan. Voor de vrijheid die zij mij gaven in het vormgeven van het ontwerp- en implementatietraject en de plezierige manier van samenwerken wil ik ze hartelijk bedanken. De heer Oudkerk in het bijzonder. Het vertrouwen dat hij mij heeft gegeven en nog steeds geeft in mijn nieuwe rol als zakelijk manager bij het Center for Medical Imaging is onlosmakelijk verbonden geweest met de snelle ontwikkeling die ik heb doorgemaakt in de afgelopen jaren.

Mijn onderzoek heb ik in de drie projecten (In VIVO, HORA 1 en HORA 2) succesvol kunnen inpassen. Echter de combinatie van adviesprojecten en het doen van onderzoek bracht ook nadelen met zich mee.

Ten eerste bleek de feitelijke tijd, die ik voor mijn onderzoek had, voortdurend in de verdrukking te komen door de adviesprojecten. In de praktijk hield dit in, dat ik ongeveer een halve tot één dag per week in plaats van twee dagen per week, onderzoek heb kunnen doen. Door deze fragmentatie had ik moeite om in de onderzoeksmindset te komen. Doordat adviesprojecten veel tijd in beslag namen duurde het traject een stuk langer dan mijn bedoeling was. Omgerekend naar een voltijds promovendusplaats, heb ik er weliswaar slechts ongeveer anderhalf tot twee jaar over gedaan, maar de totale duur was langer dan gepland.

Ten tweede bleek het voor mij lastig om aan de hoge ambities – van met name mijzelf denk ik – te voldoen. De topjournals waarin ik wil(de) publiceren vragen grote samples in het geval van kwantitatief onderzoek en een groot aantal interviews en/of documenten in het geval van kwalitatief onderzoek. Het voorgaande bleek een uitdaging met de adviesprojecten waar ik de data uit moest halen.

Tot slot hing ik tussen verschillende onderzoeksgroepen in. Ik zat niet bij bedrijfskunde en niet bij geneeskunde waardoor ik een team van onderzoekers op mijn onderzoeksterrein miste.
Op een zeker moment ben ik wel aangesloten bij het team van Janke Cohen en voor de interessante en innovatieve bijeenkomsten wil ik haar en haar onderzoekers bedanken.

Zoals zovelen bedank ook ik Roy Stewart (toonbeeld van altruïsme) voor zijn geduld en tijd om mij te leren werken met multi-level analyse en het formuleren van slimme antwoorden naar de reviewers hieromtrent.

Mijn adviesprojecten deed ik in het team onder leiding van aanvankelijk Abe Meininger en later onder leiding van Charles Brugman. Abe heeft zonder twijfel een positieve impact op mijn ontwikkeling en carrière uitgeoefend. Natuurlijk was en is er onze gezamenlijke passie voor het volleybal, maar ik denk dat wij ook een visie delen ten aanzien van de rol van de adviseur, de ontwikkeling van mensen en de politieke verhoudingen in het ziekenhuis. Abe, voor jouw hartelijkheid, opgewektheid, interesse en plezierige manier van samenwerken ben ik je erkentelijk.

Charles, en de rest van het IMVO team van het Wenckebach Instituut (Pauline Bakker, Manon Grave, Jetse Goris, Pine Remmelts, Peter Boendermaker, Rudi Hilberts en in een eerdere fase Lilianne Hercules) wil ik ook graag bedanken voor de plezierige manier waarop we hebben samengewerkt. Het management van het Wenckebach Instituut wil ik bedanken voor de mogelijkheid die zij mij heeft gegeven om het onderzoek te doen.

Ik ga weer even terug naar de aanvang van mijn onderzoek in 2005. Marjolein Achterkamp was begeleider van mijn afstudeeronderzoek vanuit bedrijfskunde en Jan Pols vanuit het ziekenhuis. Tijdens mijn afstudeeronderzoek hebben Jan en Marjolein mij gevraagd of ik promotieonderzoek zou willen doen. Nadat ik kenbaar had gemaakt dat ik daar wel oren naar had, is Jo van Engelen gevraagd als tweede begeleider van mijn afstudeeronderzoek om te zien wat voor vlees hij in z'n kuip had. Nadat Jo aanvankelijk mijn scriptie genadeloos had afgeserveerd, was hij kennelijk zo onder de indruk van mijn recovery, dat hij toestemde om als eerste promotor te dienen. Vanuit bedrijfskunde is verder Derk Jan Kiewiet aangeschoven om de methodologische kant te versterken.

Pas in juni 2007 kwam Paul Brand in beeld. Ik was al een tijdje op zoek naar iemand met gewicht in de geneeskunde. Toen ik hoorde dat Paul hoogleraar in Groningen werd, viel vrij snel het kwartje en heb ik Paul gevraagd om 2e promotor te worden. Na enig nadenken werd ik op 30 juni 2007 (via de mail uiteraard, zo is Paul, altijd erg efficiënt) verblijd met de toezegging van Paul.

Ik wil het hele begeleidingsteam bedanken, maar jullie verdienen het dat ik bij ieder persoonlijk even stil sta. Jan, ik heb veel van jou geleerd. Iedere keer na lange reflecties en beschouwingen was en ben ik onder de indruk van je capaciteiten. We hebben in de loop der jaren veel contact gehad, en ik ben ervan overtuigd dat onze discussies de kwaliteit van het onderzoek ten goede is gekomen. Ik heb onze samenwerking altijd erg gewaardeerd.

Marjolein, mijn steun en toeverlaat vanuit bedrijfskunde. Jij hebt het onderzoek onmiskenbaar vanuit methodologisch oogpunt sterker gemaakt. Jouw creativiteit en luisterend oor waren voort mij zeer belangrijk. Veel dank hiervoor! Derk Jan, we hebben elkaar niet het volledige traject meegemaakt, maar ik heb jouw inbreng voor de methodologie en statistiek eveneens gewaardeerd.

Paul, jouw no-nonsense houding, jouw ideeën, jouw enthousiasme en jouw onvoorstelbare werklust hebben mij en mijn onderzoek zeer vooruit geholpen. Zonder jou was het resultaat niet van deze kwaliteit geweest. Altijd punctueel, snel en kwalitatief goed. Ik begrijp nog steeds niet hoe je de zaak voor jezelf zo kunt organiseren. Ik ben blij dat ik je heb gevraagd, je hebt mijn verwachtingen overtroffen.

Jo, jij bent een van de meest inspirerende mensen die ik ken. Bij aanvang van mijn onderzoek ging je vrij snel naar de hoofddirectie van de ANWB, en daarna naar de Raad van Bestuur van de APG in Heerlen. Aangezien dit geen 9-tot-5 banen zijn, hebben we elkaar in de loop der jaren vrij weinig gezien. Wel hebben we elkaar met enige regelmaat gesproken via de telefoon en uiteraard hadden we veelvuldig mailcontact. Ik heb genoten van je originele, creatieve en innovatieve manier van kijken. Jij hebt onmiskenbaar de kwaliteit om mensen aan je te binden en te motiveren. Ik wil je hartelijk bedanken voor jouw inbreng en het vertrouwen dat je gedurende het traject in mij bent blijven houden en ook uitgesproken hebt. Jouw positieve woorden gaven mij op lastige momenten weer vertrouwen en energie.

Natuurlijk wil ik ook mijn familie bedanken: Mijn ouders Harry en Ali, mijn zus Kelly en haar vriend David, mijn zusje Mariëlle en haar vriend Tom en mijn opa en oma Velema. Oma Jippes, helaas heb je mijn promotie niet meer mogen meemaken. Mariëlle, jou wil ik nog even in het bijzonder noemen. Vaak hebben we het over onderzoek gehad ook omdat je nu zelf bezig bent met promotieonderzoek. Onze gesprekken zijn fijn en hebben diepgang. Veel dank daarvoor. Ik weet zeker dat je met jouw grote talent heel ver zult komen.

Uiteraard gaat mijn dank ook uit naar mijn schoonfamilie voor hun interesse in mijn onderzoek: Mijn schoonouders Gerda en Piet, mijn schoonzusje Karen en oma Leever.

Tot slot wil ik mijn lieve vriendin Marjon bedanken voor haar steun, humor, interesse en toewijding waarmee ze mij door dit traject heen heeft gesleept. Je bent fantastisch! Ik kijk uit naar onze toekomst!

Voor eenieder die ik hier niet persoonlijk heb genoemd, maar wel belangrijk is geweest; veel dank!

Erik Jippes
Mei 2012